

MODERN ARCTIC EXPLORATION

MODERN ARCTIC EXPLORATION

by

GUNNAR SEIDENFADEN



With a Preface by
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PREFACE

No man can remain unstirred in the face of the unknown and the mysterious. All through history, discoverers in different parts of the world have been continually bringing new values and possibilities hitherto undreamed-of into existence. In many places animals and plants were once the only living things where nowadays men live and thrive. Yet it was not always the desire for gain or for new dwelling-places which sent men out into the wilds. It was the unknown and the dangerous which beckoned; from far distant ages the Arctic lands have fired men's imaginations, and darkness, ice and cold have at once terrified and fascinated them.

The history of polar exploration has passed through strange phases. The desire for gain and fame, and the scientists' longing to understand the cosmic order, are only a few of the factors which impelled these countless men to set their course ever further and further north. Their enterprise has a literature of its own, and behind it lies a great tradition. Both those who went out and those who remained at home inherited the fear of death and of unknown dangers from all the foregoing generations of travellers in the Arctic, who had spoken of them and experienced them. How many have striven with Nature up there no one knows. Expeditions in search of new trade routes, whalers after new fishing-grounds — all these added to our knowledge of the cold North; but

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for all of them the struggle to preserve life had to go on side by side with the work of exploration, in a way unknown anywhere else in the world.

We have often been told that in the far North nothing changes. Time stands still, and Nature obeys different laws from those we know. This is no longer true. To-day the methods used in Arctic countries are as unfamiliar to the old-time explorer as to him who has simply followed in books the expeditions of former days.

Here is a work which contains more information than any other book written about the polar regions. The author has a practical knowledge of his subject, and sums up the past and heralds the new era in the Arctic.

Little of our earth now remains undiscovered. In the Arctic, great stretches of coastline are familiar to us, but beyond the actual territory hardly anything is known, nor could it have been until now. For we stand now on the threshold — now the sources are being tapped — and herein lies the theme of this book. This is more than the story of individual adventure; the author shows us what is known, and what we may expect to know in the future. I welcome this book as the first I have seen which combines the clarity of the scientist with the enthusiasm of the artist. I know of no work in which so much knowledge is imparted in so small a space. I myself am an Arctic explorer of the old times. I have fought my way, dog-whip in hand; I have rowed kayaks, and I have trudged long, lonely distances, dragging my sledge. I and the men with me were sometimes absent for years at a time, while those dearest to us were ignorant whether we

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were alive or dead. Such things happen no more. Wireless has done away with these long periods of uncertainty, and with the isolation which the scientist in the Arctic had once to endure.

The Arctic is now an integral part of the world. We have reached a point where we can collate the experiences of individuals, like the separate blocks of stone on a great building, and so enrich man's empire of the world. How Science and Economics work together towards this end, this book will clearly show. It has been written by a young scientist with eight years' personal experience. With the imagination of a poet he sets out the details of his subject, demonstrates the advances made in it, and opens up a new world for us all. The Arctic world is no less thrilling for the loss of its mystery, and no less interesting for our better knowledge of it. We are enabled to share in the triumphs of the men who work there, and are made hopeful of more to come.

Yet the Arctic remains under the dominion of the midnight sun and of the crushing winter darkness. Nature's variety is and remains infinite. For every riddle answered, a thousand more present themselves, and research continues to demand men of courage—men with brains and hearts and strength. I have learnt from this book that we veterans did not work in vain, and that our discoveries have contributed to the discoveries of to-day.

I congratulate Gunnar Seidenfaden on having written this book, and I congratulate his public on having the opportunity to read it. No one can turn its pages un-

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moved. I have learnt more from it than from any other book about the Arctic, for it contains more and says more than a thousand other volumes put together.

PETER FREUCHEN

Enehøje, 1939

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CHAPTER I

INTRODUCTION TO THE PRESENT DAY

From early times, polar exploration has held an important place in men's hearts. Their imagination has always been stirred by accounts of expeditions to ice-covered lands, and by news of successful encounters with cold and snow. At all times explorers have been acclaimed when they returned crowned with success won in defiance of Nature at her harshest and most violent. Uncertainty as to the fate of such pioneers has always aroused fear in the hearts of their countrymen at home, and when courageous men succumb to hunger or cold away in northern lands, the sorrow felt at their loss is a national one.

It is certainly true to say that the polar explorer represents to many people the fulfilment of their own unsatisfied yearning for high adventure. For the young he evokes the vision of a future full of excitement and renown, and for the old a perhaps melancholy recognition of a side of themselves which has never come to fruition. Speaking generally, one may say that the polar explorer has taken his place beside the popular political leader, the famous sportsman, and the hero of the screen.

Journalists say that polar exploration is always 'good copy', and has been so for thirty years at least. But the interesting thing is that discovery in the Arctic has advanced far beyond the point which it is generally sup-

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posed to have reached. The object of this book is to describe something of the revolution which has taken place in the manner of investigation during the past twenty-five years.

The old romance of the Arctic which has always captured, and still captures, the imagination of young and old, has given place to another: that of the twentieth century. It no longer concentrates on the heroic aspect, on the personality of the explorer, but rather on the thrilling tale of technical achievement, of men's ingenuity and invention, and of brilliant victory over forces really worth fighting. It is the story of co-operation and rationalisation in a development which has kept pace with that of modern industry, and in which man has taken machinery into his service, attaining thereby an undreamed-of efficiency and bringing Arctic exploration forward in giant strides.

Knowledge of modern achievements in this field must not be confined, therefore, to the few directly concerned. If the romance has altered in its nature, it is no less compelling, and enterprises to-day are worthy of the place in our minds which they have always held. This book, then, is an attempt to give some slight idea of the romance which is a reality of our own time.

But before we begin the stories of the expeditions of to-day, it will be worth while sketching in the main features of what has gone before. A revolution is never instantaneous; on the contrary, we are building now on the wealth of experience gathered in former years. No toil or hardship of the past was ever undergone in vain.

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The attitude of our parents towards exploration was sound, and one is tempted to begin by quoting Fridtjof Nansen's introduction, so rich in matter, to his history of polar exploration — *In Northern Mists* — because it gives a true and complete conception of this attitude. This is what he says.

In the beginning the world appeared to mankind like a fairy tale; everything that lay beyond the circle of familiar experience was a shifting cloudland of the fancy, a playground for all the fabled beings of mythology; but in the farthest distance, towards the west and north, was the region of darkness and mists, where sea, land and sky were merged into a congealed mass — and at the end of all gaped the immeasurable mouth of the abyss, the awful void of space.

Out of this fairy world, in course of time, the calm and sober lines of the northern landscape appeared. With unspeakable labour the eye of man has forced its way gradually towards the north, over mountains and forests, and tundra, onward through the mists along the vacant shores of the polar sea — the vast stillness, where so much struggle and suffering, so many bitter failures, so many proud victories, have vanished without a trace, muffled beneath the mantle of snow.

When our thoughts go back through the ages in a waking dream, an endless procession passes before us — like a single mighty epic of the human mind's power of devotion to an idea, right or wrong — a procession of struggling, frost-covered figures in heavy clothes, some erect and powerful, others weak and bent so that they can scarcely drag themselves along before the sledges, many of them emaciated and dying of hunger, cold and scurvy; but all looking out before them to-

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wards the unknown, beyond the sunset, where the goal of their struggle is to be found.

We see a Pytheas, intelligent and courageous, steering northward from the Pillars of Hercules for the discovery of Britain and Northern Europe; we see hardy Vikings, with an Ottar, a Leif Ericson at their head, sailing in undecked boats across the ocean into ice and tempest, and clearing the mists from the unseen world; we see a Davis, a Baffin, forcing their way to the north-west and opening up new routes, while a Hudson, unconquered by ice and winter, finds a lonely grave on a deserted shore, a victim of shabby pilfering. We see the bright form of a Parry surpassing all as he forces himself on; a Nordenskjöld, broad-shouldered and confident, leading the way to new visions; a Toll mysteriously disappearing in the drifting ice. We see men driven to despair, shooting and eating each other; but at the same time we see noble figures, like a De Long, trying to save their journals from destruction, until they sink and die.

Thus Nansen a quarter of a century ago introduced the reader to his great work on northern exploration in early times. It was the men themselves that he was interested in, and he asked himself what they were seeking away up there in the ice and cold. The answer to this was already given him by the author of *The King's Mirror* who lived in the thirteenth century. He said:

. . . it is the threefold nature of man which draws him thither. One part of him is emulation and desire of fame, for it is man's nature to go where there is likelihood of great danger, and to make himself famous thereby. Another part is the desire of knowledge, for it is man's nature to wish to know and see those parts

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of which he has heard, and to find out whether they are as it was told him or not. The third part is the desire of gain, seeing that men seek after riches in every place where they learn that profit is to be had, even though there be great danger in it.

Nansen himself, however, thought that the motive was to be found elsewhere.

. . . from first to last the history of polar exploration is a single mighty manifestation of the power of *the unknown* over the mind of man, perhaps greater and more evident here than in any other phase of human life. Nowhere else have we won our way more slowly, nowhere else has every new step cost so much trouble, so many privations and sufferings, and certainly nowhere have the resulting discoveries promised fewer material advantages — and nevertheless, new forces have always been found ready to carry the attack farther, to stretch once more the limits of the world.

Up to our own day, therefore, the history of polar exploration has been primarily the history of great names. We will review briefly the most important of these, resisting the temptation to go into details, however fascinating or thrilling. Let us content ourselves by mentioning a few of the men who had a decisive influence on the technique of Arctic voyages, whose methods were successful and whose achievements were a spur to others: men whom we could not have done without, and who have made Arctic exploration what it is to-day.

The period of the first enterprises in polar lands lies within the sixteenth and seventeenth centuries. It was

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the time of merchants and trading companies. Voyages of exploration in the sixteenth century had brought rich reward. The discovery of America and the sea route to India sent the wealth of the tropics — merchandise and precious metals — pouring into Europe. The voyages of the merchants brought about a new conception of the world, and people began to form some idea of the shape and extent of whole continents. When the English and Dutch developed into seafaring nations, and tried to compete with their southern neighbours, it was natural that they should try to reach the rich countries of the Orient by sailing round America and Asia, not to the south, as the Spanish and Portuguese had sailed, but by a northern route.¹ Thus arose the burning question of the North-West and North-East Passages, which was to fire the imaginations of merchants, sailors and explorers for a long time to come, and which was to be completely solved only towards the end of the nineteenth century. Much capital was invested, many battles were fought against the pitiless forces of Nature, and many brave men gave up their lives in the struggle before all hope was abandoned of attaining the medieval far Cathay by way of the stubborn ice-masses of the Arctic Ocean.

To the north-west we find on the map the names of the first pioneers. There is Frobisher Bay, called after the man who as early as 1576 reached the northern coasts of Labrador; and Davis Strait which John Davis, sent out by London merchants in 1585, believed to be the entrance to the North-West Passage. There is Hudson

¹ There is a map at the end of the book.

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Bay, the other supposed inlet to the sea-route, where this widely-travelled seafarer lost his life in 1610, as his crew mutinied because they wanted to return to England. The Danish expedition of 1619 arrived at Hudson Bay too, led by Jens Munk; and his *Navigatio Septentrionalis* is a unique document, recording the sufferings endured by the little group of men, of whom only three returned. But the merchants who financed these earlier voyages had bought their experience dearly, and now gave up the attempt to find the North-West Passage.

At about the same time, traders began to feel their way north-eastwards. An ill-fated expedition in 1553 made by three ships, of which only one reached the north coast of Lapland, brought about the founding of the powerful Muscovite trading-company, when Chancellor, the leader of the wintering party, went on foot to Moscow to inaugurate the communication. In 1594 the daring seaman William Barents sailed as far as Novaya Zemlya, where some years later he wintered. It was on the homeward voyage from here that he died, half-way over the sea that now bears his name.

From 1600 onwards attempt after attempt was made to press through to the north-east, but without success. Many of these voyages were led by Hudson, who discovered among other places East Greenland. But even if they did not have the longed-for result, their consequences were not without practical advantage. His stories of the countless whales and 'sea-cows' found round Spitzbergen resulted in the great Ice-Sea fisheries, in whaling and in seal-hunting. These flourished for a

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couple of hundred years and played an important part in the history of English and Dutch trading, in which the Scandinavian countries also shared.

Much later, when the Russians had made their way through Siberia to the coast of Asia in the east, discovery continued at this end of the 'Passage'. Not until 1741 did Bering discover Alaska, and the commerce done in this part of the world gave rise in 1798 to the Russo-American Trading Company.

Apart from this, few Arctic voyages were made in the eighteenth century. For one thing these trade routes had been abandoned as the southern ones became better known; the southern Europeans were falling behind in commerce, and the north-western Europeans took over their routes and markets.

Not until the beginning of the nineteenth century was interest in the North-West Passage re-kindled. The reasons for this were many. The Napoleonic Wars had claimed the strength of the nations until then, but after the peace of 1815 attention could once more be turned away from Europe. In Alaska, the aforementioned activity of the Russians, who were feeling their way eastwards along the north coast, aroused the alarm of the British, who feared to be forestalled in North America. At last, as a final incentive to John Barrow, who was at that time Secretary to the Admiralty and keenly interested in geographical matters, there came news from English whalers off Scoresby Sound (East Greenland) that ice conditions in the Arctic Ocean were unusually favourable. In 1818, therefore, John Ross made his long



top: WHALING IN THE NORTHERN ICE SEA IN THE 17TH CENTURY
From an engraving in Zorgdrager's *Greenland Fishing and Whaling*, 1723

bottom: ONE OF THE FIRST STEAMSHIPS
Hayes's ship leaving Jakobshavn in Greenland. Here again the artist had never been to the Arctic.



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voyage to Melville Bay and Smith Sound; the first of a series of British expeditions.

We now come to the second period of enterprise in Arctic regions. The merchants' desire of gain was no longer the driving force, but national interests. Britain's imperial interests were now involved, and it was the English officers' 'emulation and desire of fame', to quote once more the phrases from *The King's Mirror*, which led to the discoveries in the first half of the century.

The most illustrious name among the many which distinguish those years is that of Edward Parry. He was notable not only for his geographical discoveries and for his contribution to our knowledge of the north-western parts of Canada, but also for the excellent organisation of his voyages. Before his day it had happened all too often that whole ships' companies were lost as a result of bad food and conditions. Parry realised that if men were to winter in the Arctic, their spirits must be kept up, they must lead a regular life, and they must enjoy a varied diet which should include fresh meat. His winter camps became patterns for all who came after him. Not only did he have cleanliness parades and medical inspections; he also cheered his men by bringing out a newspaper at regular intervals. He even let them produce and act a play which he himself had written, *The North-West Passage*, or *The End of the Voyage*. And what was at least equally important, he taught posterity that crews need not be confined to the narrow quarters on board while their vessel is ice-bound. As soon as the light permitted, he sent out spring reconnaissance-parties

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in all directions. His little two-wheeled cart, on which his men could stow provisions and equipment to last them for some time, was the forerunner of the sledge, and his journeys with it were the first of the sledge-journeys of to-day.

Parry's voyages took place in the 1820's, and were not confined to the North-West Passage. He visited Spitzbergen too, and with his sledges reached Lat. $82^{\circ} 45' N.$

In taking a stride further in the history of the North-West Passage, we are arrested by the name of John Franklin. It was in 1845 that the British Admiralty resolved to make a really big effort to win for England the honour of discovering this route. Two ships, the *Terror* and the *Erebus* with a crew of a hundred and thirty-four, were fitted out, and sixty-year-old Sir John Franklin, who had distinguished himself in other parts of the world, was chosen as leader. The octagenarian Sir John Barrow, who had sent out so many other marine expeditions, was also a moving spirit in this enterprise. The ships left England on May 10th, and on July 26th they were hailed by a whaler off Lancaster Sound in Baffin Bay. From that moment no more was heard of them, and at the end of two years such anxiety was felt that rescue expeditions were started.

The following years are characterised by the number of these expeditions. Several attempts were made to send vessels by the same route which Franklin had followed. Search-parties made their way up the Canadian rivers, while ships were fitted out and sent through the Bering Strait. In the course of the next twelve years thirty-nine

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ships and six land-expeditions were despatched. To follow the histories of these different excursions, by which the fate of the Franklin expedition was gradually disclosed, is a study in itself. It was not until the MacClin-tock expedition of 1858 and the American lieutenant Schwatka's voyage in 1879 that it became at all possible to reconstruct the miserable fate which had overtaken Franklin and his men. It was then known that having been ice-bound for three years in the northern straits, Franklin decided to abandon his ships and lead his men southwards along the Great Fish River to the Hudson Bay Company's stations in Northern Canada. The history of this tragic journey, which not one of the hundred and thirty-four men survived, Lieutenant Schwatka was at last able to trace.

Nevertheless, the Franklin expeditions, whose history is a source of thrilling tales and a record of tragic incident and brilliant achievement, led to the charting of the great Canadian archipelago and to the discovery of the North-West Passage.

To sail northwards round the American Continent to the miraculous lands of the East was not the rapid matter that medieval traders had imagined. On the contrary, the voyage was made in the opposite direction, after years of suffering and hardship.

In the early spring of 1850, Sir Robert MacClure sailed round Cape Horn and right up through the Bering Strait. Continuing eastwards along the northern coast of America, he came upon straits which led farther in the same direction. Here he was compelled to winter;

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nevertheless, in the autumn of the same year he reached with his sledges those sounds which hitherto had been approached from the east alone. He now knew that the North-West Passage had been found, but it was only after a stay of several years in these parts that he made contact with expeditions from the other side, and not until 1854 did he return to England.

With the discovery of the North-West Passage and the tracing of the fate of the Franklin expedition came the end of the 'British Naval Period' in the history of polar exploration.

The new and important factor in the expeditions of the latter half of the last century was the leading part which came to be played in them by the scientists. Observations of scientific interest had of course been made before; it is for instance largely to the ships' surgeons of the Franklin expedition that we then owed our knowledge of the conditions and inhabitants of the polar countries. But it was now understood that side by side with geographical research a scientific investigation of these lands should be carried out, with that of their animals and plants, their geology and their climate. It was also realised that this research could best be engaged upon from winter base-camps ashore.

This new type of exploration had its first beginnings in the region separating the islands of Greenland from those of Canada; it was here that the great Smith Sound expeditions were made, under the leadership of such men as Kane (1853), Hayes (1860), Hall (1871), and Nares (1875). One of the chief questions occupying

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scientific minds at the time was that of the 'Open Polar Sea'. It was believed that, thanks to the Gulf Stream, there must be a navigable channel round the North Pole, so that, if only the intervening belt of ice could be penetrated, there would be no difficulty in sailing directly to the North Pole. It was this theory which led to the forming of the Smith Sound expeditions; many years passed before it was dropped, and many men wore themselves out in the attempt to reach the promised water beyond the ice-barrier. Nevertheless, observations made by the members of these expeditions were most valuable, both in the information about climatic conditions which was gained, and in the field of natural science.

But it is above all the Swedish expeditions which we have to thank for the great scientific knowledge won from the Arctic towards the close of the nineteenth century. These expeditions concentrated chiefly on Spitzbergen, and were begun by Otto Torell, but the most prominent name of all is that of Nils Adolf Erik Nordenskjöld. From 1858 onwards he accompanied the Spitzbergen expeditions, and soon took over their leadership. He realised the importance of taking with him scientists of all kinds. It is to him that we owe the first thorough survey of Spitzbergen, he made the first accurate meteorological observations from pack ice, and it was his scientists who gave us a thorough knowledge of Arctic creatures and plants, of geological conditions and many other things. The peak of his brilliant series of successful expeditions was the *Vega* voyage in 1878-9, on

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which not only was the North-East Passage navigated for the first time, but also a wide knowledge was gained of the northern coast of Siberia.

Since Nordenskjöld's time it has been an almost invariable rule for scientists to accompany Arctic expeditions, or indeed that these should be carried out expressly for the purpose of solving some scientific problem. European scientists began to take a greater interest in Arctic questions; thus in 1881 we had the first 'International Polar Year', in which a number of countries sent expeditions to the Arctic, in order to obtain correlated, simultaneous meteorological observations from all the regions round the Pole. Of these Polar Year expeditions the one led by the American Greely to Smith Sound is the best known, on account of its disastrous ending. Owing to bad ice conditions the relief expeditions arrived too late, and only a handful of men were saved, after appalling sufferings. Greely's account is perhaps the most tragic document in nineteenth-century polar history.

It would take too long to relate more of the enterprises of this period. A single name stands out, because it is that of a man in whom were combined the best qualities of an Arctic explorer: a keen scientific brain, a great gift for organisation and a steadfast and heroic strength of character.

Fridtjof Nansen had already become famous through his journey across the inland-ice of Greenland in 1888. He now worked out a theory of the currents in the polar sea, and in order to test it evolved a brilliant plan.

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With a specially constructed wooden ship, so built that under pressure of ice she would be forced upwards instead of downwards, he planned to drive her into the ice of the polar basin, and drift with it. On September 22nd, 1893, his ship, the *Fram*, became jammed in the ice north of the New Siberian Islands. Three years later on August 14th, 1896, she came out north-west of Spitzbergen. Nansen had proved his theory, and shown the direction of the drift of the ice-masses of the Polar Sea from the north coast of Siberia towards the East Greenland ice-stream.

But by then Nansen had long abandoned the ship, for in the course of the westward drift he had perceived that she would not pass right over the North Pole, as he had hoped. In March 1895, therefore, he and Hjalmar Johansen left the vessel and sought a way northwards. However, they had to abandon the idea of reaching the North Pole, for the ice over which they laboriously toiled was drifting rapidly to the south. Instead, these two courageous men came southwards again and wintered in Franz Joseph Land, not returning to Norway until the following year.

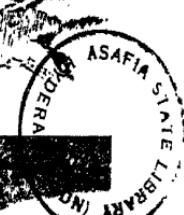
The end of the nineteenth century drew on. During the last half of it there had been a great advance in exploration. But many regions still remained undiscovered, and so far no one had yet set foot upon the top of the earth. The first man to do this was the American engineer Robert Peary.

In 1886 Peary had embarked upon his long series of expeditions, of which the most important object was the

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conquest of the North Pole. His plan was to press forward with sledges from the inhabited regions round Smith Sound to the northernmost part of the mainland. On his preliminary expeditions he explored North Greenland, and the journey he made with the Norwegian Astrup across the inland ice of Greenland to the great ice-free Peary Land was among the best-known of his enterprises. Through these journeys he exploded the theory, hitherto firmly held, that Greenland extended all the way to the North Pole. Peary's great significance in polar exploration lies in the fact that he not only learned the art of dog-sledging from the Eskimos, but co-operated with these people to a great extent, and indeed brought their technique to perfection. He made a strenuous effort in 1906; and in 1909, after twenty-three years' work in the Arctic, he reached the longed-for goal. On April 6th he was able to set foot at the Pole which, as had been expected, proved to be located in the middle of an ice-filled sea.

By his journeys in northern Greenland, Peary had confirmed Nansen in showing the practicability of the inland ice as a thoroughfare, and from his time right up to our own day numerous expeditions have crossed it. During these years, Arctic exploration was, generally speaking, concentrated round Greenland, and one may perhaps mention the 'Danish period' which followed upon the Swedish. In the years up to 1913, the whole of the east coast was explored, and we can here note such men as Holm, Ryder, Amstrup, J. P. Koch, and Ejnar Mikkelsen. After that, under the leadership of Knud



top: THE FIRST DOG-SLEDGES

The artist who drew this had never been in the arctic regions and this picture shows his imagination at work on the subject

bottom: ONE OF THE FIRST WINTER-STATIONS

Greely's station "Fort Conger" on Ellesmereland



INTRODUCTION TO THE PRESENT DAY

Rasmussen, we have the long line of 'Thule Expeditions', which either originated or received support from Knud Rasmussen's colony Thule, in North West Greenland. The most important of these were certainly the first and second to North Greenland, and the fifth great expedition, the object of which was the study of the various Eskimo races between Greenland and the Pacific, with particular reference to their interrelationship, origins and the course of their migrations. Here may also be mentioned the great expedition north of Greenland, the 'Jubilee Expedition' which was led by Lauge Koch in 1921-3, and was so named because it marked the bi-centenary of Hans Egede's landing in that country.

These later enterprises have in common the fact that they embodied all previous experience. The Eskimo sledge technique was used, and an important thing was that men were now learning to live off the country. By using animal life as food for men and dogs it was possible to reach more distant objectives than those attained by the earlier expeditions.

But in the early 1920's, when the crushing burden of the World War was lifted from men's shoulders, the great wave of modernism rolled forward over the civilised countries. And just as it meant an alteration in the structure of our own society, so also it had a decisive and far-reaching influence on Arctic exploration. This new structure is the subject of the following chapters.

In attempting to review briefly the methods which in the course of time have been used in Arctic exploration, we shall find it easiest to recall the names of the men men-

MODERN ARCTIC EXPLORATION

tioned in the foregoing account, and note what have been the contributions of individuals.

The first method was the use of the sailing ship. By this, man was subject to whims of weather, and remained a pygmy in the struggle against the ice-masses of the Arctic. If the ice forced the seafarers to winter in the north, this winter was spent in the cramped quarters on board, and men tried to keep alive by means of what provisions remained to them. Seamen were unaccustomed to leaving the ship; scurvy and depression were the results, and although there were examples of unparalleled heroism in the history of those crews, the gains were small and the disasters many.

Parry gave his men lemons to eat. He cheered them in the darkest times and insisted on order and cleanliness. As soon as the light permitted, he sent them out on excursions over the surrounding ice. The second method was thus introduced, characterised by the sledge; and now journeys were taken in spring and autumn, when the Arctic sun hung low in the sky and the water was ice-bound.

Time passes. The polar explorer learns to leave his ship, and build houses ashore. He is confident that the steamship, which he sent home in the autumn with the rest of the men, will not fail to fetch him next year. And from his winter-station he explores the country. He has the scientist with him, and he himself is perhaps not a ship's officer, as one in his position would have been in earlier times. And now that he has learnt the length of time that the coasts remain ice-bound, short summer

INTRODUCTION TO THE PRESENT DAY

expeditions are made. So Nordenskjöld brings his experts up into the Arctic.

1900. Peary settles down among the most northern races of the earth. He sees in them people who for generations have accustomed themselves to the peculiar conditions of the Arctic and have learnt how to deal with them. He realises that visitors from the south must learn from these intelligent, and in their way highly specialised people; and from them he borrows the dog-sledge: a means of transport which to this day retains its value.

But the twentieth century sends a host of technical discoveries through the world, and they reach even the far north. The explorer with the glamour of adventure about him gives place to the staff of experts. They are indebted for their weapons and tools not to the single men, but to technicians, inventors, craftsmen and scientists all over the world. The many-sided Arctic traveller, the great polar explorer, is dead; from him we take up our heritage, and the monument we raise to him is Modern Arctic Exploration.

CHAPTER II

THE MODERN EXPEDITION

If we regard the modern expedition as an integral part of the great mechanism of life to-day — and this, it seems to me, should be our aim before we approach it from a nearer standpoint — we can do it most simply by using expressions and concepts borrowed from national economics. It is easy to regard exploration as the first stage of Production—even though it be a production of which perhaps we do not see the results, in the form of materials for the satisfaction of human needs, for many years. It was really this which *The King's Mirror* spoke of, when it mentioned man's desire of gain. The old merchants and trading companies were also mindful of the productive side when they sent out their ships on Arctic voyages, even if they foresaw that a single expedition might not be profitable. And in reality it is the productive aspect which induces states and individuals in our own day to invest in such enterprises.

Thus in essentials an Arctic expedition differs very little from what in economics is known as a 'production-cell', and we can liken it most nearly to some modern industrial undertaking. At first glance, such a comparison may seem artificial and far-fetched, but we shall see that the similarity on many decisive points is extraordinarily striking, and we are hereby enabled to see the matter in a new and truer light.

MODERN ARCTIC EXPLORATION

By seeking help from economic concepts we shall be enabled also in a simple, fundamental way to define the differences between ancient and modern Arctic exploration. Economists regard production as a combined working of three essentials—Land, Labour and Capital. This conception is easily applied to the question with which we are here concerned, for the object we desire to gain through a modern expedition is the exploitation of Arctic Land in its widest sense (including land, water, and animal and plant life) by employing on it our Labour, so far in the shape of scientists and explorers, and our Capital in the shape of the equipment of these explorers.

The difference which so sharply divides ancient and modern exploration is that to-day, by a far greater and more far-seeing use of Capital and equipment, we are able to handle our Labour with greatly increased efficiency. In earlier times, the expert—whether scientist, technician or cartographer—could make only a very limited use of his abilities. On the sledge journeys of the primitive expeditions, the first consideration was the mere preservation of existence; in a continual struggle for life, men had to labour with their own hands to get themselves food, to keep alive and to push on. It was the continual complaint of the explorers of those days that there was so little time or opportunity to undertake the research which was the object of the whole enterprise.

The expedition of to-day takes Capital into its service in the form of highly perfected technical apparatus. We have carried the Machine with us to the Arctic, and through it we take the fullest advantage of our experts.

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This development is one which has taken place simultaneously with the one at home: the Industrial Revolution has found its way up into the Arctic.

In borrowing from industry the use of the machine, Arctic exploration at the same time took on the form of industry, its organisation and its thorough rationalisation. The polar explorer of early times was many things — sledge-driver, hunter and fisherman — while in science he had to know something of every branch. Modern explorers have understood the Division of Labour as well as the motor manufacturer or the professor who buys himself a ready-made suit.

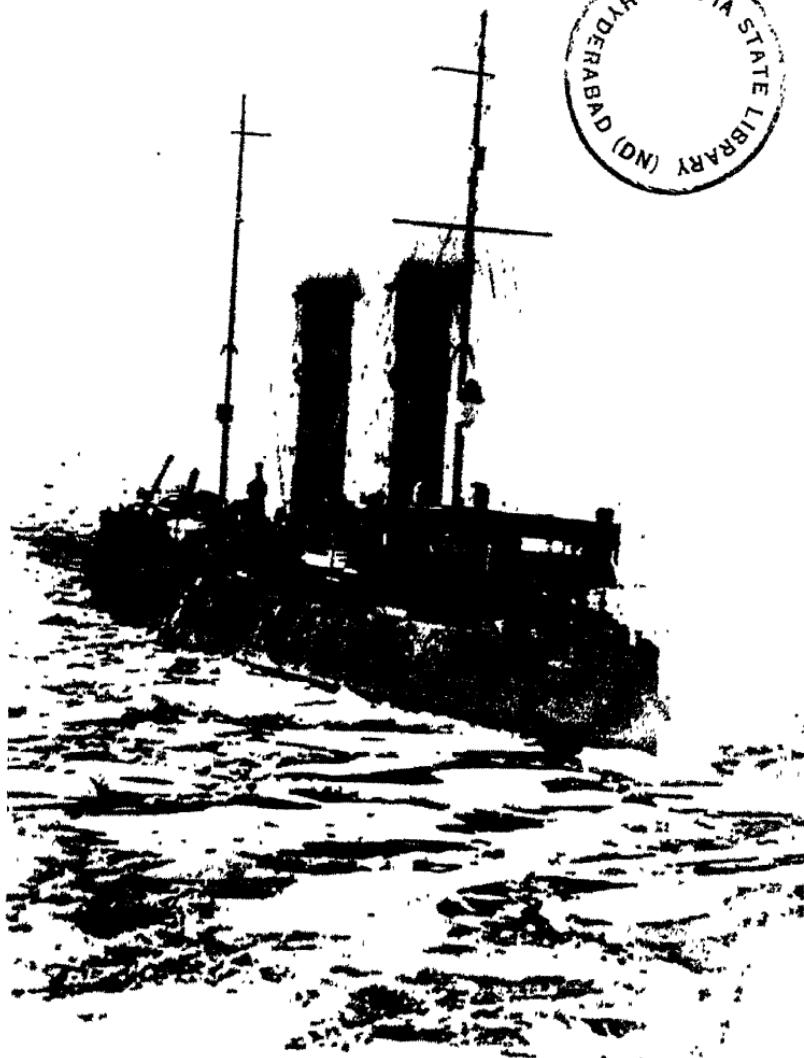
When, therefore, in the following pages we consider the most marked characteristics of the modern expedition, we must explain the manner in which the capital is invested. That is, we must give a survey of the machines and technical instruments used; furthermore we must examine the peculiar structure of the expedition of to-day, we must see how the work is organised, and in what way research is carried out. First we shall consider the expedition as a whole, describing its equipment and its work on the spot, its means of transport, its safety-service and the rest of its workings: finally we shall approach each branch of its science in turn, follow cartographers, biologists, and marine research-workers in their various fields, and see what instruments and what methods they make use of to attain their object. Each of these branches will be dealt with in a separate chapter, therefore, but first let us take the expedition as a whole.

In the foregoing chapter the progress of development

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was shown from the first sailing-ships to steamships, and from the time when these vessels were used as winter quarters until special winter-stations were built, or the crews spent the winter among the local inhabitants. This line of development has been carried further in recent years. As far as the ship is concerned, this advance has admittedly been slow. The old wooden vessel propelled by steam and sail, dating from the beginning of this century, has persisted up to our own times, because she is very serviceable in polar ice, which consists of massive floes of varying size and thickness. Between these floes narrow channels sometimes appear, and it is these which make it possible for a little ship to wriggle her way through the labyrinth, where a larger ship could not pass. Furthermore, the old wooden vessels have an elasticity not possessed by ordinary iron ships. (The pack ice is formed in the polar basin, and from the edges of the central massif round the North Pole the floes are carried south by the currents. Latest research suggests that even the central parts are sometimes, if not every year, broken up.)

Of recent times, however, the technique here also has been changing, and the innovation comes chiefly from Russia. The attempt has been made during these last years to keep a route open for cargo-steamers, from the mouths of the Siberian rivers to the ice-free waters of the Bering Strait and Norway. It is true that in part the nature of the ice along the Siberian coast differs from that of the polar ice, because of the water flowing into it from the rivers, but even so the passage is sufficiently difficult. To help the traders, therefore, modern ice-



THE KRASSIN, A MODERN RUSSIAN ICEBREAKER

The *Krassin* took part in the rescue of those who crashed in Nobile's expedition of 1928



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breakers are used. Here we need only name such vessels as the *Lenin*, the *Jermak* and the *Krassin*—these are the three biggest. Of the smaller ones, the *Taimyr* and the *Murman* will be best known, for it was they who at the end of February 1938 rescued the Russian explorers from the ice-floe off the east coast of Greenland. The names, *Malygin*, *Sedoff* and *Sadko* may also be familiar, for it was these ships which were trapped in the ice off the New Siberian Islands, with a convoy of eight merchant vessels; and their fate is still unknown at the time of writing. The *Jermak* has engines of about 3,000 horse-power—as a comparison it may be mentioned that the Danish East Greenland steamers have under 300—but not even this is enough to get the better of the ice on the route from the Siberian river-mouths.

For these reasons the Russians began in 1936 the construction of four new ice-breakers, of which two must be near completion. These are powerful steamers of 12,000 tons (about the same as the smallest Cunarders). They have modern Diesel-electric engines developing 10,000 horse-power. These engines mean easier transport, more convenient fuel-storage (oil instead of coal), and the Diesel-electric combination greatly facilitates the handling of the ship. Each vessel carries two aeroplanes which are launched by catapult. Their wireless equipment is not only in touch with the coastal stations, but is also in direct telephonic communication with the head office in Moscow.

With these giants it is hoped that the route may be kept open during the summer months for vessels trading along

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the northern coast of Siberia. They are so strongly built that they will be able to be used with advantage in heavy polar ice, being capable of withstanding great pressure; and with their powerful engines they will force their way along the channels between the floes, even if they are unfitted for ice-breaking in the true sense among such masses as these.

It is possible, therefore, that these new ice-breakers will be the pattern for the ships used in future in the exploration and exploitation of the Arctic. However, owing to their costliness, they will not yet quite supersede the good little wooden ships — at any rate not where exploration pure and simple is concerned, uninfluenced by such economic considerations as are involved in the development of the Siberian continent.

Ships continue to be the most important means of transport for Arctic expeditions. Aircraft have so far not the loading-capacity necessary to enable them to supersede ships altogether, even though the time is perhaps not far distant when the difficulties of pack-ice will be avoided simply by passing over it. Aeroplanes have already shown their great usefulness in the relief of crews of polar-stations difficult of approach; we may mention here also the fixed air-routes along the Siberian rivers. Then there is the rescue of expeditionary parties which, owing to special conditions, cannot be reached by ships, as has happened in East Greenland in particularly unfavourable years. In time, as flying technique develops and the machines can carry greater loads, and as our knowledge of the Arctic grows and the number of

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meteorological stations increases, aeroplanes will undoubtedly come to play an increasingly larger part as a means of transport in polar regions.

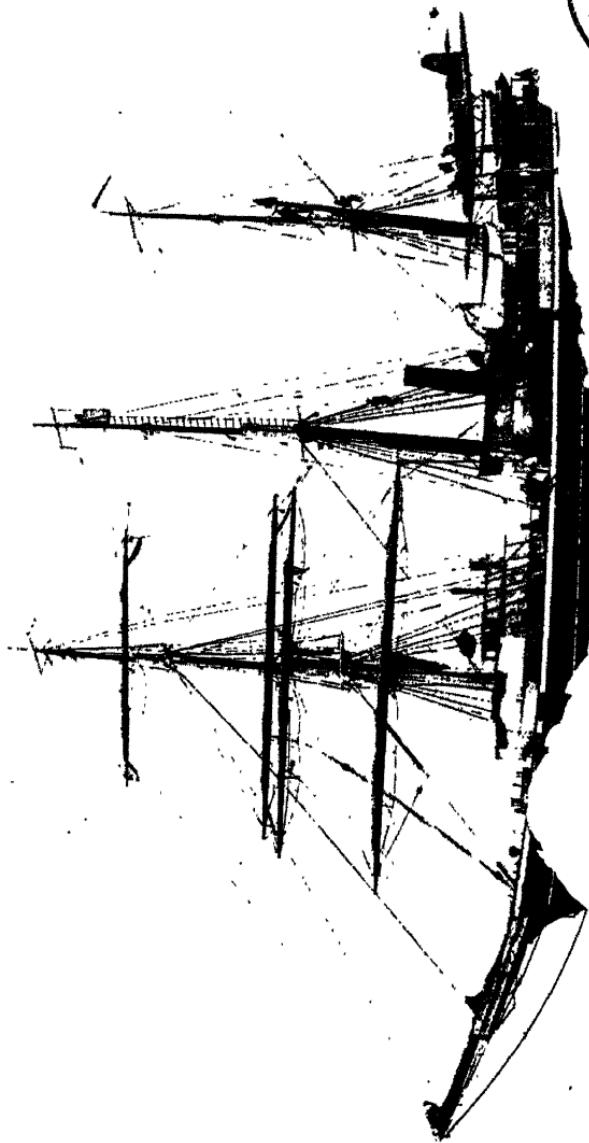
With the other type of aircraft, dirigible airships, more difficulties arise. Airships have certainly been used successfully several times in the Arctic, but the disadvantage of them lies partly in their greater sensitiveness to changes of weather, but mainly in the difficulty of landing, which usually requires special conditions — a larger crew, a specially-built landing-mast, and so on. Moreover, all aircraft in the Arctic run the risk of becoming coated with ice, which is especially disastrous for airships because of their large surface, and is dangerous also for aeroplanes. Attempts are just now being made to solve this problem, either by warming the wings electrically or by some other means; and the Russians and Americans are working out a method which consists in covering the wings with a layer of rubber, threaded with air-passages which can be alternately filled and emptied, so that the layer of ice cracks off.

Aeroplanes already play a very big part in the circumnavigation of Arctic lands, and fulfil important piloting duties. In sailing through the labyrinth of narrow channels in the polar ice, it is, of course, of the greatest importance to make for places where there is most open water. From the mast-head one can see for a distance of about four nautical miles, but if the vessel carries a seaplane the problem is solved. She makes her way to some stretch of water large enough for the seaplane to take off; soon the machine is in the air, the ice spreads out beneath

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it like a map, and the observer can make a sketch showing which course the ship must steer. This pilot-service has been of outstanding importance for the Danish East Greenland expeditions, and has saved much valuable time. In the channels of the Russian Arctic, where greater economic interests are at stake, it is only necessary to telegraph to the nearest airport, of which there are several along the northern coast of Siberia. Soon afterwards an airman is circling above the ship; he radio-telephones the first information, then sets off on a reconnaissance of the route ahead, and makes a chart of the ice, which is dropped on to the ice-breaker by means of a small parachute.

Once the ships have arrived at the scene of operations, the aircraft have a varied task. They now enter the service of the scientists, on mapping-flights, or in flights with the geologists, such as will be described in the later chapters. But they also take part in general practical work. They carry small working-parties to the areas where research is in progress, and this makes it possible to save time, and also to reach places which would otherwise be difficult of access. Seaplanes can set men down on an isolated lake, or at the ends of fjords whose entrances are blocked with ice. They can circulate information among those working-parties who have no wireless sets with them, they bring medical aid, and help the workers in other ways. In the course of the Danish work in East Greenland, the value of aircraft was brought home to us very strongly. A wireless report came through from one of the camps that their motor-boat had broken



THE DANISH POLAR SHIP *GUSTAV HOLM*
She is built entirely of wood, and carries a sea-plane



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down. One of the cog-wheels had gone. Ten minutes later a mechanic was on his way to the spot with his tools. Another station reported that a man had hurt himself, and immediately the doctor scrambled into the machine with his bag. The day the mail packet arrived at the colony of Scoresby Sound, south of the place where the members of the expedition were at work, a machine was there to fetch newspapers, letters and certain important spares for the air-photography apparatus. We were uncertain what had become of a working-party of which we had heard nothing for some days; the machine found the fjord in which their motor-boat was, found the camp, and learned that it was only their wireless transmitter which was out of order. The value of aircraft in modern Arctic exploration cannot be exaggerated.

Other means of transport are also at our disposal in these days. We must not omit some mention of the motor-boats, which in recent years have come to play so large a part in the exploration of East Greenland fjords, and other coastal waters in the Arctic. Even in the far north, the many channels between islands are ice-free in summer, and here the speedy little motor-boat comes into its own. It renders the individual expert independent in his movements. He leaves his base with his assistants as soon as the ice breaks in the spring, or as soon as the ship touches land, and only when provisions or fuel are to be renewed need he get in touch with this base—and not even then if, as is most often the case, the mother-ship has seen to the placing of depôts at convenient places. On the Danish expeditions to East Green-

MODERN ARCTIC EXPLORATION

land we had only two large ships, and three or four fixed stations ashore, but throughout the summer more than a score of motor-boats large and small were in operation over that great coastal area, each carrying its little working-party, usually composed of scientists in the different branches: geologists and their assistants, botanists, zoologists and archæologists.

The members of earlier expeditions were in summer confined to rowing-boats necessitating a large crew, or else they had to make use of native craft, the 'women's-boats' of the Greenlanders and the ramshackle craft of other Arctic peoples. So the motor-boat, too, has contributed towards greater efficiency.

To turn now to winter transport: when the fjords are covered with ice, and the land with snow, we must, of course, go to work in another way altogether. Now the dog-sledge, which we have copied from the Eskimos, plays the most important part. We have perfected the technique. We have built stronger, lighter sledges, and shod the runners with nickel, so that they slide more easily. And above all we have lightened the loads. The introduction of primus stoves and modern tinned provisions, and the use of light, reliable rifles of long range, seem so natural to us now that we almost forget what they mean to the traveller with the sledge. At the end of the last century he had to bring heavy sacks of coal with him, barrels of salted food and hard ships' biscuits. The tents were heavy and difficult to handle, whereas ours are thin and light and at the same time stronger and of more closely woven fabric. But the most import-



WITH A DOG-SLEDGE ACROSS THE INLAND ICE OF GREENLAND

(Compare the old imaginative engraving facing p. 32)



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ant factor is unchanged — we still use the Eskimo dog, and the traveller must learn the technique of the Eskimo; he must learn to swing his whip or tread out the trail at the head of his animals.

Nevertheless we may anticipate great changes in this field too, and certain experiments have already been made with a view to introducing modern methods into winter transport. Except for the very darkest period of the year, aeroplanes can be used, for they are then furnished with skis, and a level starting-place is found for them. In the south polar regions, which we shall not discuss here, these methods have been brought to great perfection; but many expeditions have made use of aircraft in the winter too, in Asia, America and Greenland. In the latter region they were used by the English Watkins expedition which was working in South-East Greenland, and whose aim was to observe flying conditions there. This expedition was part of the general investigation carried out in connection with the projected air route between Europe and America.

To bring sledging technique up-to-date has also been tried, though with less success. Motor-sledges are difficult to handle. Sledges driven by propellers have been tried several times, as in the Wegener expedition of 1930-1 for the transporting of materials from the west coast of Greenland to the middle of the inland ice, where a scientific winter-station had been established. However, a propeller-driven sledge has necessarily to move at considerable speed, and this requires an even surface; a thing seldom met with over large areas in the Arctic.

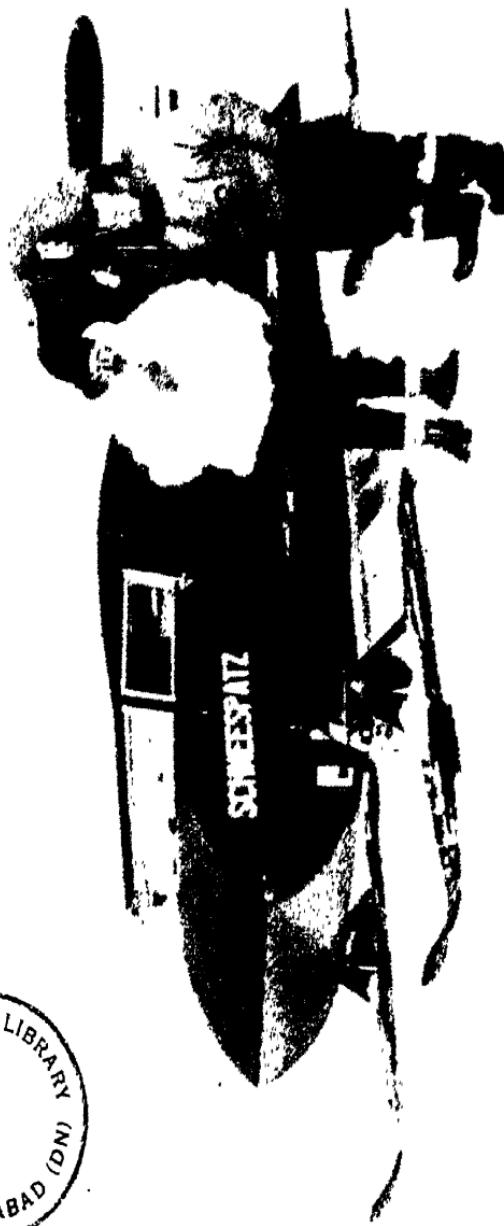
MODERN ARCTIC EXPLORATION

There have been experiments also with tractors harnessed to the sledges. Such an attempt was made by Dr. Lauge Koch in Northern Greenland in 1922, and was found rather successful. The tractors dragged Koch's materials up the steep route from the base to the edge of the inland ice, but up on the ice itself and down by the fjords the dog-sledges still proved more serviceable. The tractor is too heavy, it gives out entirely in deep snow, and if the going is very rough many men are needed to handle it. Tractors have been of some service on the frozen rivers of Canada, where they are used as locomotives for provision sledges.

It may be that the Americans have the right idea in trying to use a sort of small tank with caterpillar wheels. The great advantage of a tank is that it can move over very rough ground, and yet at a fair speed. It is possible that a modified version of this modern weapon of war will become in the future the chief means of transport, during the winter months, in the peaceful conquest of the Arctic. For actual exploration, however, it is likely that the dog-sledge will long remain in use, especially in areas which cannot be reached in the summer, or by air, and above all on long journeys when sufficient food and fuel cannot be carried and man must shoot for himself and for his dogs as he goes.

In earlier times it was natural to choose an inhabited district for one's base, and to undertake sledge-journeys at seasons when there was snow. To winter in a ship far to the north, away from people, as we saw in the previous chapter, had certain disadvantages, and

ONE OF WEGENER'S PROPELLER-SLEDGES





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most expeditions only used their ship as a base in summer. But as early as the end of last century, when scientists came to be important members of an expedition, it was realised that a more complete exploration of the country could best be made by building special winter-stations, so that the members had a permanent and secure refuge in the middle of the area to be explored. Modern expeditions have learnt from this, and of late years winter-stations have been built farther and farther north. In 1937-8 men wintered near the North Pole!

Winter-stations nowadays offer the most favourable conditions to the scientist and his helpers. In describing such a scientific base one could take an example from among the numbers which have been erected in the course of recent years along Arctic seabords; but it seems natural to speak of the stations in East Greenland, where since 1931 a stream of Scandinavian and other scientists have carried on research all the year round, six hundred miles north of the Arctic Circle, very nearly if not exactly as they would have carried it on at home.

Two of the East Greenland Stations, Ella Island and Eskimonæs, are fitted out exactly alike, and built to house at least eight men. To facilitate their construction in the short time there was at the explorers' disposal, they were built in Copenhagen; that is to say, the main parts were assembled with the aid of bolts of wood and iron, the individual pieces were carefully fitted and marked with colours and numbers. They were then taken down again and transported to Greenland, where the building of them was more like a large-size child's puzzle

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than real joinery. As a result of the experience gained on former expeditions, each man had his own little room; and besides these there was a big common-room, a laboratory, a workshop and a wireless room. In the out-houses there was space for gear and tools and reserve provisions, skis, sledges and dogs; and in a special built-on shed was the electric-light plant. Naturally electric light is laid on all over the house. Not only is it the best light to work by, but it is also cheap, clean and handy, and not the least of its advantages is that it reduces the danger of fire, which for such an isolated station would be disastrous. The electric current is used also for the big wireless installation which is included in the outfit. In this way the men remain in continual communication with the outside world, and the fact that they can amuse themselves with American and European broadcast programmes is not without importance. The food is as varied as modern canning can make it, and everything possible is done to obtain as comfortable working conditions for the scientists as possible. There are Greenlanders attached to the station, to look after the big dog-teams, and to initiate the explorer into the mysteries of the art of handling the sledges. The stations are supposed to be visited every year and the men relieved, but provisions for at least two years are always stored, in case ice prevents the arrival of the relief-ships.

Naturally the existence of such a winter-station is of enormous importance in the survey of any region. For one thing, the scientist and his equipment are brought right to the spot, and he no longer has to battle his way



A MODERN WINTER-STATION

A moonlight photograph of Ella Island Station, East Greenland, January 1934



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forward on exhausting, time-wasting journeys. He is stationary, and is thus enabled to embark on experiments or keep biological phenomena under observation for an indefinite period. He is also able to start reviewing and classifying his collection, thus revealing at once any gaps in his material while there is yet time to fill them. But here is another advantage for the scientist in the winter-station, no less important for being indirect. He feels at home in the comfortable surroundings, he can devote all his energy to the solving of problems, and above all he has a sense of security, knowing that this refuge is at hand, with its shelter from the storm, its copious stores of provisions, and its light in the winter darkness.

Not least among the elements contributing to this security is wireless. Only a few years ago the Arctic explorer had to bid good-bye to the outer world for many months when he set off to spend the winter in the north. He heard nothing at all of what was going on, or how his family were, and those at home had no news of him. It was perfectly natural, and one would often be without news of the men wintering in the north for a very long time before feeling anxiety and sending an expedition after them — which often came too late. Now we can sit comfortably at home, and by telephone ask the nearest wireless-station to enquire as to the whereabouts of the party; and in a few hours we have our answer. And not only safety and security are won in this way. The scientist can keep up with the latest developments in his own line, and can also make his report to those at

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home, so that he may perhaps receive further indications of how to proceed, or have more assistants sent out to him if the results gained require it. For the leader of the party it is important to be able to report what has been used, eaten or worn out in the course of the past year, so that the necessary stores may be replenished by the next ship.

But wireless is not important only for winter-stations in the Arctic. In the big modern summer expeditions it plays a tremendous part, for ships, motor-boats and aeroplanes. The use of radio in daily work has become so common a thing that a member of a modern expedition can hardly imagine how earlier explorers managed without it.

As the ship approaches the working-area, wireless waves are already running on ahead. The nearest winter-stations are communicated with, for information as to ice and weather conditions. The air-pilot is sent up, and from his transmitter we learn the appearance of the ice-labyrinth before us. Meteorological stations warn us in good time of wind or fog, so that we can take precautions.

When the expedition has arrived at its destination, and the many working-parties have been set ashore along the coast, or have left the ship in their motor-boats, there is a great deal to do at the base headquarters. On modern expeditions, the smallest camp is provided with wireless equipment. This is not at all large and its construction is founded on experience gained by amateurs, in their experiments with short waves. Transmitter and receiver

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are built together in a little box and the current is supplied by dry batteries or by the engine of the motor-boat. And so the ether above the Arctic lands is filled with wireless waves. The motor-boats report their positions several times daily, they give an account of their findings, their plans for the next few days, and their requests for the establishing of depôts.

The permanent camps report how the work is going, and what provisions they have, and they summon the ship when they have done all they can in one place, and want to be moved elsewhere. From the air-base, the wireless-operators follow the machines as they set forth across the ice, or over the great mountains.

This whole system contributes enormously towards the safety of any enterprise. The margin of accident is considerably reduced — or perhaps one should say rather that the possibility of warding off misfortune has been correspondingly increased. In adding to efficiency, wireless has been invaluable. The individual scientist can be supported and helped at almost every point. The number of costly 'wasted working-days' is reduced to a minimum. In the old times, when a working-party was separated from the main expedition, the two groups provided each other beforehand with a mass of complicated alternative arrangements, which usually involved numerous misunderstandings, and nearly always meant that people had to wait for each other without being able to get on with anything, or else that work had to be broken off before it was finished. The leader of the expedition, therefore, could not allow himself to divide up the main

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body into any great number of parties. With wireless to help him, he can now remain at the centre, from which an almost unlimited number of parties may be sent out and yet remain in touch with him.

From the survey made in these last few pages of the importance of wireless in modern exploration — a subject to which we shall be inevitably compelled to return — we have glimpsed something of the organisation of the expeditions of to-day.

A modern expedition is characterised first of all by its meticulous planning and preparation. Our knowledge of the Arctic lands in general, and of the conditions to be encountered there, makes it possible to decide beforehand down to the last detail how the expedition shall be conducted. We are aware to a certain degree of the problems we shall be brought up against, and can make a plan of campaign for tackling them. We know whether the place which the individual scientist is to examine can be reached by ship, boat, horse, dog, or aeroplane; and we can, therefore, decide not only what branches of science should be represented there, but also where and how the research shall be carried out from day to day. We know the weak points in our plans. We know at what time and place conditions of ice or weather can intervene and hinder us, and we can provide ourselves with an alternative programme.

Earlier expeditions have taught us in detail the external conditions under which we shall be working, and we can therefore exercise the utmost forethought in choosing equipment. We can provide the men with the appro-

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priate means of transport, and the proper scientific apparatus; we know what provisions are desirable, and in exactly what quantities.

As we have seen, all such things increase efficiency, but they also make preparation an exacting task. The very fact that we can specialise makes it necessary for us to think out every detail in advance. The months immediately before the start of an expedition are nothing but a succession of hectic days for the leader and his assistants. Nothing must be forgotten if all the working parts are to fit smoothly together into one whole.

When the expedition arrives at its destination, work is carried on along a wide front. On her way along the coast, the mother-ship sets ashore the many little working-parties, and stores of provisions and fuel are left at places previously agreed upon. It may be that winter-stations are to be built, too, for scientists who want to remain in the region. Days in the short Arctic summer are precious, and so this work must be done promptly. The motor-boats are ready to be swung into the water. The equipment of the experts is packed in easily-handled cases, plainly marked. The provisions are already stored in rations, in boxes holding everything that the men can need in the course of any given number of days. Timber and furniture for the winter-stations are clearly marked, so that they can rapidly be set ashore and put up. The essential conditions for smooth running are, of course, that all preparations be made at home, and that everything be stowed in its proper place in the hold so that it can be brought out at the right moment.

MODERN ARCTIC EXPLORATION

Co-operation is the keystone of the modern expedition. The numerous parties are scattered over a wide area, and are separated from one another by great mountains, glaciers and fjords. But invisible wireless-nerves connect them with the controlling brain. Thus they can take the fullest advantage of their time, and they can also help each other in their work. Experts doing the same research in different places can let each other know how far they have advanced. The geologist among the mountains can ask to have aerial photographs taken of the region he is in, and soon afterwards the machine is humming over his head. If problems arise which he cannot solve alone, help is at hand.

The specialist is a self-contained unit in the modern expedition. We carry him up to the Arctic with all his equipment — his whole laboratory — and give him the same working conditions as at home.

But perhaps one of the most essential features of the modern expedition is that it does not cease to exist after the scientists have returned home. The work goes on along the existing lines. Results must be classified, the collections examined and maps made. And finally everything must be made public; until then the expedition is not over. And the leaders remain at the centre of things, maintaining the same contact between the scientists, who superintend the editing and publishing of articles and contributions by the members of the expedition. The examinations that have been made may produce a whole series of new problems, and perhaps another group is sent out to continue the work. In this way we get a

THE MODERN EXPEDITION

continuity in exploration, which adds still further to its efficiency.

It is in Russia that organisation has been brought to its highest perfection. Here the exploration and exploitation of all that part of Siberia lying north of the 60th latitude have been put under a special Ministry or administrative department: Glavnoye Upravlenya Severnovo Morskovo Puty, or Glasevmorput, as it is called in everyday speech. The chief of this is the celebrated Professor Otto Schmidt, and the staff numbers 40,000 people. They are divided up into scientists and technicians, telegraphists and ice-breaker crews, agricultural students, doctors and miners. From this organisation expeditions are sent out to all parts of vast Arctic Siberia, and decisions are made as to the advantage to be taken of the different discoveries. The aviators of the administration not only maintain regular communication between the new settlements that are springing up in the tundra, but they also take part in the exploration of the regions round the North Pole, they act as pilots for the ice-breakers and run an ambulance service among the native population of the coast.

It is, of course, the vast area of Arctic Siberia which accounts for the enormous personnel attached to one administration, and in any case, speaking of Russia one must reckon with other figures than those one is accustomed to use in western Europe. But the fact should not be ignored that the commercial view taken of it may be harmful to accurate research, as such a pyramid of people easily tends towards bureaucracy. So we can

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MODERN ARCTIC EXPLORATION

hardly compare Glasevmorput with modern exploration elsewhere, as it is chiefly concerned with the *development* of the Arctic. But if the economic-minded reader asks us of what use the modern expedition is to the community, we shall be able to find many satisfactory examples among the Russian activities.

It is perhaps here that we come upon the next stage in Arctic exploration, which lies outside the scope of this book, but can even now be guessed at. It is the stage at which the pioneer's activity becomes a thing of the past, and at which the Arctic regions, and the life and work in progress there, is a natural, logical part of the community, with its own administration, its own permanent officials: a self-supporting machine, parallel to all other community-machines to which we are accustomed.

The modern expedition represents the transition to this stage. With its lengthy preparation, and the long period of work remaining after the journey itself is over, it is assuming the character of something permanent. The time will come when the actual expedition, while remaining the natural climax to a period of work, will be a thing apart, of no more and no less interest than the general life of the department of Arctic investigation at home.

CHAPTER III

MAP-MAKING

In the autumn of 1907, when strong northerly gales gave warning of the approach of winter, and the light grew dimmer every day, three men fought their last hopeless battle for life in the extreme north-east of Greenland — the part that they themselves had been the first men to see. After exhausting journeys in the spring, and an enforced summer stay, with no sledging surface, they were now attempting with worn-out dogs and without provisions to go from the inner end of Denmark Fjord up over the inland ice, and down to 89° N., to Lambert Land, where they knew there was a dépôt. From here the journey could be continued along the coast home to Danmarkshavn.

They met with appalling difficulties. In the growing darkness they dragged themselves over the ice through a labyrinth of deep, treacherous crevasses; and starving though they were, they showed a heroism unusual even in the history of Arctic exploration. But in this race with death which was being run to save the results of their labour, the map of this most remote district of Greenland, they were the losers. Only twelve miles from the dépôt, Mylius Erichsen and Höeg-Hagen found graves in the ice.

Only the Greenlander Jörgen Brönlund dragged himself as far as the dépôt. He knew that he too would die,

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and that he would never get further south; but he also knew that if the maps and journals could only be brought to the Lambert Land dépôt, they would be found sooner or later by the relief expeditions, and the records which had cost the three men their lives would be saved. In the last days of November he arrived. With a pair of sledge-runners he made himself a little shelter; here he lit a primus, and lay for five or six days. The precious maps he put into a box at his frozen feet. He bound these in bits of skins and made his will, then drew his anorak hood over his face. His last message was as follows:

Perished Fjord 79 after attempt return over the inland ice in November. I came here in waning moon, and could not get farther for frost-bitten feet and darkness.

The bodies of the others are in the middle of fjord opposite the glacier (about two and a half leagues away). Hagen died November 15th and Mylius about ten days after.

Jörgen Brönlund.

And here it was that Colonel J. P. Koch, on his arrival three months later, found the maps which for years were the only ones of that region which we possessed.

The history of exploration through the last hundred years gives a long series of such examples. Tales are told of men whose craving for discovery drove them to seek out new tracks of land, to chart the unknown islands and straits which had hitherto been indicated on the map by uncertain dotted lines, or which were known only by verbal information from whalers or travellers

MAP-MAKING WITH A THEODOLITE FROM A MOUNTAIN-TOP





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who had seen distant, dark mountains on the horizon, beyond miles of pack-ice. The story of cartography is a dark, dramatic one, and tells of the crews of frozen-in sailing-ships who suffered death from hunger or scurvy, or lonely travellers with sledges who had to leave their dead comrades in the snow, while the number of their dogs dwindled day by day. Yet at the same time it is the story of heroic achievement with theodolites and measuring instruments in biting cold; of desperate endurance in the struggling progress from headland to headland, in the piecemeal discovery of new fjords and new islands. Ancient, legendary lands, round which many tales had been spun, disappeared, but new, true countries came in sight and were mapped, with their glaciers and promontories, their rocks and islands.

The instruments of the nineteenth-century cartographer were few and fairly primitive. The seaman had his sextant, with which he took observations of prominent points of the coast; later the sledge-traveller took his theodolite with him, and could determine the chief peaks and coast-line, and by means of strenuous climbing he could reach the heights and survey part of the country. The theodolite is still an essential instrument, being necessary for astronomical determinations of position on the earth's surface. This measurement is fundamental to cartography, and is also the basis of navigation during all journeys made in the ice-masses of the Polar Sea, or over the monotonous surface of the inland ice. But the theodolite is now regarded as a slow, clumsy instrument for topographical survey, and early carto-

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graphy often resulted in inaccurate maps, or in maps of very small areas at a time.

Maps of Arctic regions show how our knowledge of these lands has grown with every expedition, step by step, area by area. Often by the names on present-day maps one can read the history of exploration. Look, for example, at the map of the central part of the East Greenland coast, which to-day is among the best-known regions in the Arctic. At one of the most easterly promontories we meet with such an ancient name as Hold-with-Hope. This was the first point to be established; here, in 1607, the gallant Captain Hudson saw a new and unknown coast, and held fast with hope in his fantastic attempt to reach China via the North Pole. Otherwise this coast is marked with names like Bontekoe, Gael Hamkes, Borlase Warren, Broer Ruys: names that speak plainly of the old Dutch whalers who in the seventeenth century so boldly fought their way along the coast. These discoveries called for a closer investigation, and if we follow the map up into the fjords, we shall find among the names there a reminder of the more accurate charting of the shore within limited areas, undertaken by the scientific expeditions of different nations. To the north we find names like Hohe Nadel, Schwarze Wand, Zackenberg, Teufelschloss, Germaniahafen; a German expedition has left plain traces here, to be succeeded farther south by the British Clavering expedition (1822), with such names as Cape James, Jordanhill, Young Inlet, Loch Fyne and many more. And still farther to the south we strike names that bring us nearer home — Mästers Vik, Pol-

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hems Dal, Segelsälskapsfjorden, Konung Oscar Fjord. It was the Swedish Professor Nathorst who explored this region, and his reason is given in the names of Andrée Land, Fränckel's Peninsula and Strindberg's Peninsula: it was the search for the Swedish balloonists of 1898 that was the purpose of the expedition.

Nevertheless it is the map of just this part of Greenland which carries us into the present. The foreign names are those of fjords and lands, of great glaciers and prominent headlands. If on our modern maps we look behind the high coastal ranges, which often soar, vertical and unscalable, from the sea, and follow westwards to the edge of the inland ice, we suddenly come upon quite a different set of names. Here we find Holger Danske's Peak, Greisdalen, Krumme Langsö and Ole Römers Land. These are regions remote from the navigable fjords, far from the places which the sledge-traveller could reach with the primitive means at his disposal. These are summits, lakes and lands which could not be seen even from the highest peaks on the fjords; and the names bear witness to the detailed Danish cartography which has been done in the most recent years, and which has been made possible only by the help of modern methods. We have arrived at the latest period in the history of Arctic map-making — the age of flying.

As has already been mentioned, the aeroplane and airship came into use in Arctic regions in the decade after the World War. They brought about a revolution in the exploration of regions which had been inaccessible on account of either high mountains or impassable ice-

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fields. In the twenties it became possible to carry out a whole series of reconnoitring cruises up and down and across the most northern areas, and to ascertain just how little country actually remained to be discovered. Most of the cruises over the region of the North Pole itself revealed only ice, ice and yet more ice. Aircraft were not yet used in more accurate cartography; on the contrary, their high speed made the fixing of points very difficult. It was only through a parallel development of another sort of technique that aeroplanes and airships became of such great importance. Now for the first time the significance of photography began to be appreciated, and it was particularly with the perfecting of photogrammetric methods that a revolution was brought about in the mapping of the Arctic.

The chief object of this chapter is to give an account of modern photographic methods and their use in the Arctic, and we must begin with the principles of photogrammetry.

The human eye is constructed like a small camera. The lens is situated at the pupil, and the back of the eye, the retina, receives the picture like a photographic plate. As we know, it is only when we look at a thing with both eyes that we are able to determine its distance from us. The reason for this is that the two pictures formed in the two eyes are not exactly similar; because of the distance of the eyes from each other, one of them sees more of the side surfaces than the other. In our brains these two images melt into one and give us the impression of depth. Experience has shown that we are able to per-



A GLACIER, ABOUT A MILE AND A HALF WIDE, THAT HAS CUT ITS WAY DOWN AMONG THE MOUNTAINS



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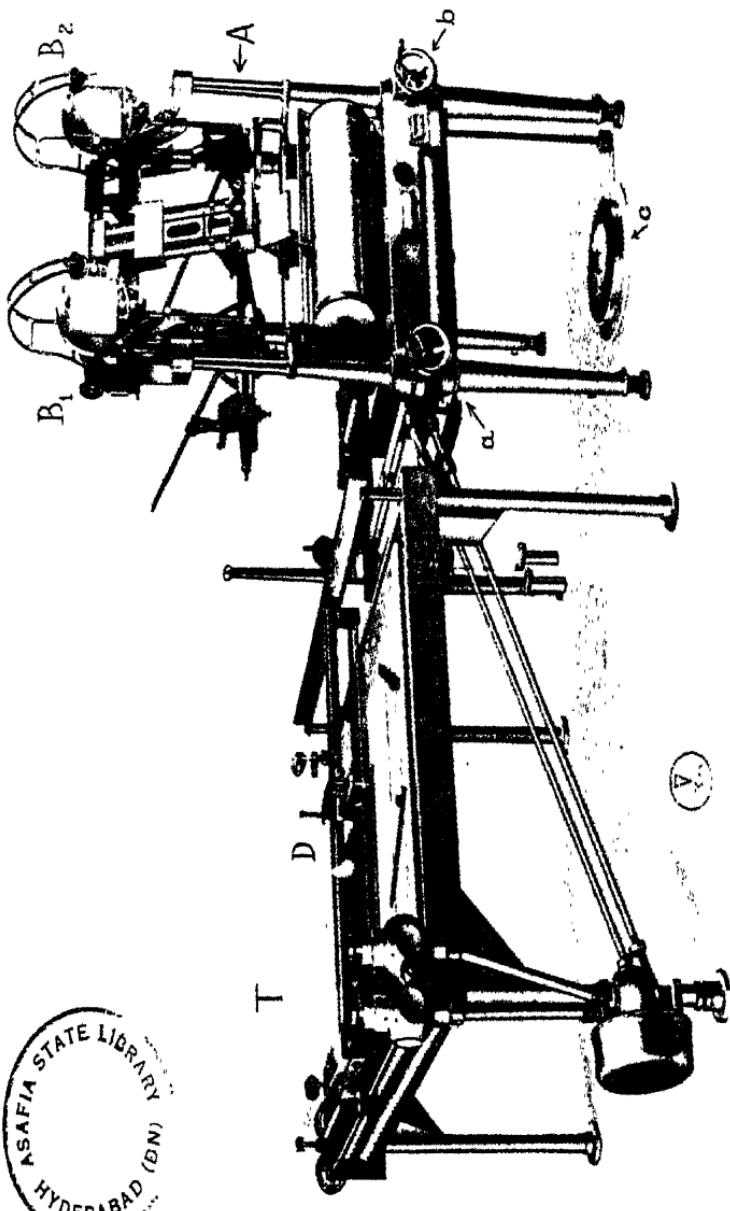
ceive difference in the distance of objects up to within fifty times the distance separating the two pupils. This is not much when we come out into the mountain landscapes of the Arctic; but here it is that the camera comes to our aid. This renders the distance between our two pupils much greater, simply by taking two pictures of the same thing — the same mountain district — with cameras set up in two places, at a considerable distance from each other. Supposing, for example, that we decide to take pictures of the same landscape from two places separated by a distance of two kilometres, it will be possible for us to obtain a very pronounced impression of changes in the relative distances of objects lying within fifty times two kilometres: that is to say, within 100 kilometres (about 60 miles). For this it is essential to get the two pictures to fuse into one as do the two images on our retina. This we are enabled to do with the help of a complicated and ingeniously thought-out machine, called a stereo-plotter. In this apparatus (see illustration facing page 66) there is a stereoscope, in which our two pictures (B_1 and B_2 in the diagram) are placed, and by a system of prisms and lenses they are brought into correspondence when we turn a certain series of screws. If we look into the apparatus (at A) the picture stands out in relief and we get an impression of distance and depth — we see valleys cut in between the ranges, and mountain-tops standing out one behind the other. Just by looking into this instrument we can see a convincing view of the mountain landscape we have photographed.

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But the stereo-plotter can do much more for us than this. As its name indicates, it is itself a plotter, a map-maker. For in the lens-system of the stereoscope there is a mark, which is apparently floating in space and free, and by turning certain handles (*a*, *b* and *c* in the diagram, *c* is turned by the foot) we can set it wherever we like in the landscape before our eyes. The interesting thing about this is that by a series of incredibly delicate and accurate levers, this wandering mark is connected with the other half of the plotter, the drawing-table (T). Here lies our paper, and as we move the mark by the handles, a pencil at (D) moves correspondingly over the paper. We can now understand the great value of the plotter. Supposing, for instance, we see the picture of a fjord in front of us, we can, while looking into the apparatus, turn the handles and cause the mark to follow the coast-line of the fjord in the picture. And when we have traced the whole outline of it in this way, there on the table lies a map showing its form. We then move the mark to a mountain-top — and there is the pencil, its point indicating the corresponding position of the peak on the map. The movement of the mark takes place in three dimensions — forward and back and sideways on the horizontal plane, and up and down the mountains. It is now clear that if we fix one of the movements — the one up and down, for instance — at a certain height, so that we can only move the mark horizontally, we shall, by following the surface of the ground with the mark, obtain a contour-line just at the height where we fixed it. Without a more detailed explanation, it will perhaps

A. STEREO-PILOTTER

The working of this machine is explained in the text





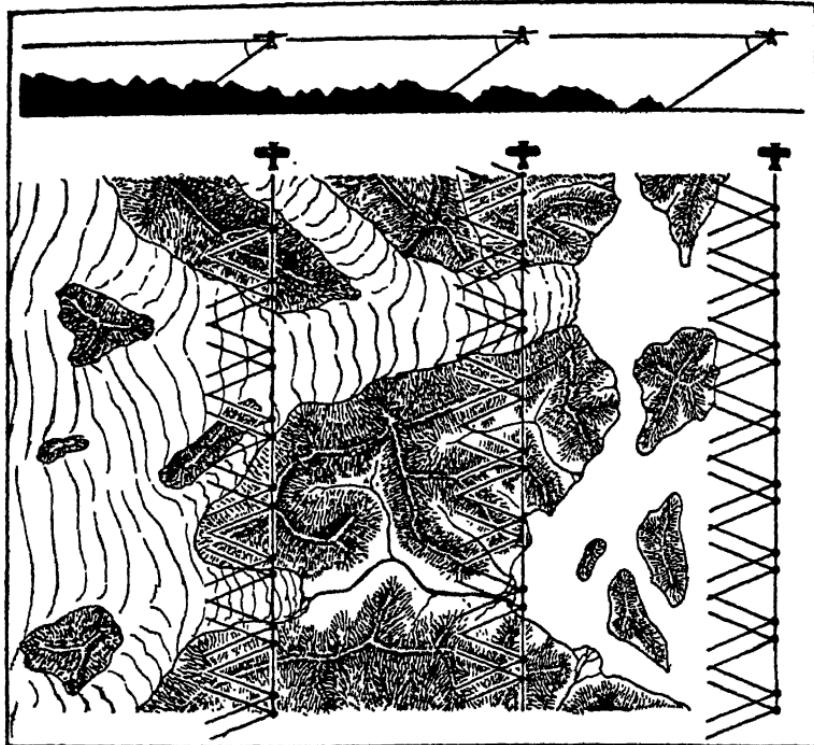
MAP - MAKING

be evident now that with the stereo-plotter it is possible to draw a complete map of the region shown in the picture; a perfectly ordinary map, showing coast-lines and contours with their relative distances, rivers (one can let the sight follow the water-courses in the picture), mountain peaks, and so on. It is necessary, however, to base the survey on a skeleton framework made in the usual way, by fixing the chief peaks on the spot, in what is known as a triangulation-net, with the help of the theodolite, and determining the position of the net in latitude and longitude. The more complicated methods of working this out I shall not touch on here, but it may be mentioned that in this field also wireless has made improvements possible, as we can now receive time-signals from European stations, and attain a higher degree of accuracy than was possible with the old chronometer.

This use of the camera has meant a tremendous advance in map-making, when it is a case of mapping an inaccessible region in a comparatively short time, and without great expense. By simply setting up two cameras at two different places on the shores of a fjord, and photographing the opposite coast, we obtain a map of the area along it. But that is not enough for us. We want to learn about the country behind the coastal mountains, we want to determine the dividing-line between the inland ice and the ground which is free from ice, we want to record larger areas on one pair of pictures than is possible down in the narrow fjord, or from the ship lying off-shore.

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It is the aeroplane which carries our artificial eye up over the summits, makes it possible for us to peep behind the mountain walls, and carries us into the interior, to the edge of the inland ice. It is by co-operation between



SKETCH OF THE PRINCIPLE OF AERIAL PHOTOGRAPHY FROM THE
ORIGINAL BY L. BRUHN

camera, aeroplane, and the stereo-plotter that modern map-making is done; and how different this complicated mechanism is from last century's pencil sketches with frozen fingers, slowly working sextants or theodolites and clumsy dog-sledges!

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We must now hear a little about how the photography of the country is done. The pictures or pairs of pictures cannot be taken in a haphazard way; we must be sure of getting a record of every area, yet at the same time we must not waste film or fuel. The sketch on the opposite page, which I have borrowed from the leader of the Danish East Greenland Cartographic Expeditions, will help us to understand the methods used.

The camera is set slantways beneath the aeroplane in such a way that the greatest area possible is recorded in the picture. The aeroplane flies on, taking its pictures two by two with a suitable "pupil-distance" between them. But we have already seen that when features of the landscape lie more than a certain distance away from us, our judgment becomes unreliable; therefore another series of pictures is made farther inland, and the machine flies back parallel with its earlier course. If the land is too broad to be adequately covered in this way, we must take a third and perhaps a fourth set still farther in. It is this process which is represented in the picture. Above we see the country in relief, to the right the aviator is out over the sea, at a height of 13,000 feet, and the lines indicate how much we shall see on our pictures. Below we see a bird's-eye view of the area, with the parallel courses laid at distances of from twenty to twenty-five miles. The black dots mark the points from which the photographs are taken, and we see that these pictures go in pairs, the distance between them representing the distance between the pupils. When all these pictures have been taken we can return home with

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the certainty that the stereo-plotter will draw a detailed and accurate map for us.

But none of this is as easy as it sounds. Let us go up to East Greenland and follow one of the Danish mapping-aeroplanes on a photographic tour.

It is the summer of 1933. In the dead calm of the natural harbour at Ella Island, H87 lies moored at its buoy. H87 is the seaplane which the navy has put at our disposal; it is a Heinckel with a Jaguar-engine of 450 horse-power, and a cruising speed of over 100 miles an hour. Up at the other base of the Three Year Expedition, Eskimonæs, there is another similar machine which is to be used in photographing the land in the north, while we cover that in the south.

The aerial photographer's first duty is to keep an eye on the weather. There must be clear air and no mist lying in the fjords. One is sometimes compelled to wait for days on end, and even though the weather may look favourable from down on the coast, it is quite possible that the machine may have to return as soon as it gets high enough for us to get a view of the country, and we see that after all there is mist or fog.

But this morning it looks fine. The aerial photographer routs out his companions, who live in large tents beside the machine. They must wrap up well before they go up, for it is very cold at 13,000 feet. The flying-suits are of thick lambskin, and, once inside, the men look like big, clumsy polar-bears. We pull out to the seaplane in a dinghy, and get in. In front sits the

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pilot. His is a responsible task, for not only must he steer and see to the engine as usual, but he must be careful to follow a dead straight course at the same altitude. Behind him sits the wireless operator, the guardian of our safety. While the plane is in the air, he remains in constant communication with the base, for the flying takes place over uninhabited and inaccessible regions, and if anything goes wrong the news must be transmitted at once, so that help may be brought as quickly as possible.

Farthest aft sits the photographer. Where he works the plane has no floor. The camera is slung in heavy metal rings, so that by altering the position of the frame he can change the direction in which the photograph is to be taken. Naturally this is no ordinary camera; on the contrary, in its technical ingenuity it is a fairy-story in itself. Behind the compact, solid shell, which allows only the powerful lens, the handle and the leads to be seen, there are interrelated mechanisms. The photographs are taken on a strip of celluloid 20 metres (66 feet) long, and 15 centimetres wide. After each picture taken a new surface of film is automatically exposed, the shutter is set, and everything is ready for the next photograph. All this is done by electricity, and attached to the side of the plane is a little dynamo, propeller-driven, which supplies the current. On account of the cold, an electric warming-apparatus is fitted inside the camera, and there are still more things hidden in this magic box. There is an automatic counter, which shows the number of the film now being exposed; there is a clock with a big second

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hand, and an altimeter, also a small plate giving the number of the route. These things are fitted on to a little instrument-board which is lit by an electric light, so that the whole thing is photographed at the same time as the view. In the aerial photograph facing page 72, the instrument-board will be seen at the side, so that one may know at once on looking at the picture when and how and at what height it was taken.

The most important task of the aerial photographer is therefore to take the picture — to press the electric contact at the right instant.

The aeroplane has gained the proper height. Photographer and pilot have agreed beforehand what course shall be followed to-day. These have numbers, and now the pilot's voice is heard in the earphones of the photographer: 'Ready for photographing on course 406 west.' The route-flying begins. With strained attention the pilot's eyes watch the altimeter and compass, and the photographer has his stop-watch in his hand. After the first exposure is made he has hardly time to assure himself that the mechanism is working properly before the second of the pair of pictures must be taken; for in 45 seconds the plane is already two kilometres farther on her course. Then there is a pause for 135 seconds; six kilometres farther we shall have the next pair of pictures. Five seconds before each exposure a red lamp goes on in front of the pilot, so that he can turn the plane exactly to the given course.

The whole thing looks very simple, but actually the aerial photographer is subjected to great strain. Con-



AERIAL PHOTOGRAPHY FOR STEREOPHOTOGRAHMETRIC USE

This gives some idea of the impossibility of mapping these formations from the ground (East Greenland, 1933)



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stant attention is the main thing; and besides this, at certain intervals, the film must be changed, and notes taken when moving from one course to another. And if the electric mechanism gets out of order, as is apt to happen in severe cold, the film must be shifted by hand by means of the emergency crank on the outside of the camera. Remember too that we are at a height of 13,000 feet, where every movement in the rare atmosphere demands greater effort than on the ground. The photographer must move about his small compartment in his clumsy clothing like an acrobat; he must reach the apparatus at the bottom of the aeroplane and take care not to wreck all the strings and leads—the wires of the camera and his own telephone—to say nothing of the parachute harness and the rudder-wires along the sides of the machine.

The fliers cannot keep up this work for more than four hours at a time, they then have to return to the base. If the weather remains good, advantage must be taken of it, and another crew is ready to go up. But the photographer gets out with the precious boxes containing the film he has exposed. To assure himself at once that he has been successful, he must develop the films immediately. At home in Europe this could easily be done with a large dark-room at one's disposal. In the Arctic it is more difficult. In East Greenland we built small dark-rooms, which had to be erected on land beside a lake with clear water, so that the films could be properly washed. And in this little room where, since the films are panchromatic and sensitive to red light, all the work

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must be done entirely in the dark, the photographer manœuvres his 60 feet of film amongst basins and chemicals, and has difficulty, too, in keeping the solutions at the temperature necessary for good developing. Only after a long spell of tiring work can he roll the film on to the big drying-drum, report the result of the day's photography to the leader, and take his well-earned rest. On his survey map the leader can now trace the route with his red pencil — a sign that we are so much further on our way.

I have gone in this detailed fashion into the methods used in East Greenland, because the work here was the first big, organised attempt at aerial cartography ever made in the Arctic. The method of oblique photography of landscape has been used also by the British and Norwegian expeditions working in the same region.

But this method makes it essential that one should have plenty of time at one's disposal, since several flights have to be made over the same bit of country. By flying along the side of a fjord, for instance, a picture can be obtained of only one side of it, and the camera must afterwards be turned the other way to photograph the land opposite. There are also many other ways of making maps. It might seem most natural to take the pictures vertically, so as to have a map ready-made; and this has been done at home, where detail is wanted. It is evident, though, that in the Arctic one would have to attain a great height in order to photograph enough at once to make the enterprise economically practicable. The best plan would be to have a whole set of cameras,

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one pointing straight down and the others out to the sides. Particularly in cases where it is possible to fly only once over a region — for instance on the long trans-polar flights — would such an arrangement be almost indispensable.

Modern invention here comes to our aid once more. Instead of a whole set of cameras, of which the pictures by an almost impossible process would have to be fitted together for mapping purposes, the German engineer C. Aschenbrenner had the simple, brilliant idea of building them all in one. Then was constructed his nine-lensed camera, which takes at a single exposure one vertical photograph of the land immediately under it, and eight round the horizon. In the first of the two pictures facing page 76 we see nine separate photographs taken on one plate, and by putting these in a special apparatus they are united as seen in the second of the two pictures, giving a much larger area than would be possible with a single-lensed camera; and this picture can be used in conjunction with another taken a kilometre farther on in exactly the same way as that which we used in East Greenland.

Aschenbrenner's camera was used in the Arctic on the *Graf Zeppelin's* flight in 1931. Here, owing to the difficulties of landing and of renewing the fuel supply, it was possible to fly over the unfamiliar areas only once; and the camera helped to secure for us maps of the unknown parts of Novaya Zemlya and the Taimyr Peninsula, and above all of Severnaya Zemlya north of Cape Chelyuskin, which at that time was almost entirely unknown.

MODERN ARCTIC EXPLORATION

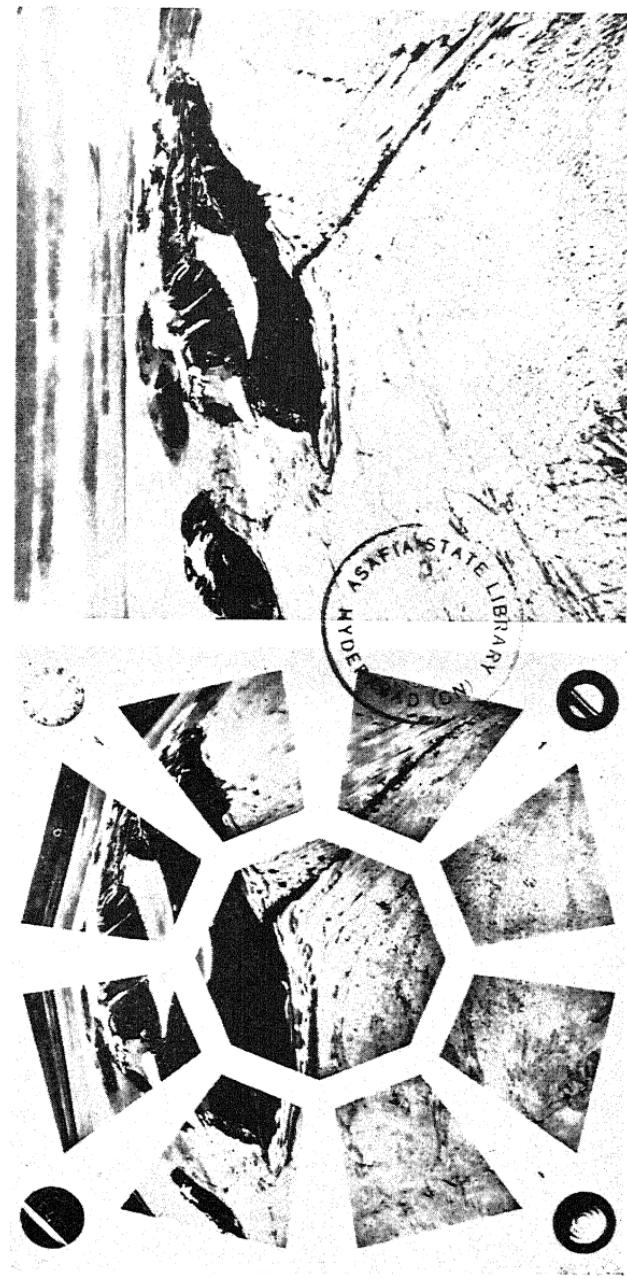
Aerial cartography of Arctic regions is now making rapid strides. In the eastern part of the North American archipelago, Canadian expeditions have traversed the country. In East Greenland the Danes have photographed almost the whole of the coastal area between Prins Christian's Sound and Danmarkshavn, a distance of about 1,100 miles, and maps are being issued which altogether will cover 100,000 square miles. The Norwegian expeditions have photographed large areas in the central part of East Greenland, and their maps will be a valuable check on the Danish ones. In the summer of 1936 the Norwegians began also a great mapping campaign in Spitzbergen, which was continued through the summer of 1938, so that the whole land is being mapped from the air. Parts of Taimyr and the North Siberian Islands were photographed by the Graf Zeppelin expedition, and the Russians themselves are continuing the work. We may expect to have within a few years completely up-to-date maps of all the land in the Arctic, for development is going forward rapidly, and in hardly any other field of polar exploration have modern methods played so predominant a part as in cartography. The regions round the Pole itself, which explorers took hundreds of years to discover, and whose uncertain bounds cost endless struggles and many lives to determine, will in the course of only ten years be known in the greatest detail; and every river and glacier will be traceable on a map which in accuracy is equal to those of our own country.

Nearly ten years ago, the Swedish Professor Helge Backlund and I went ashore at the inner end of a little-

A PHOTOGRAPH OF SEVERNAYA ZEMLYA TAKEN WITH AN ASCHENBRENNER CAMERA

On the left: Aschenbrenner's original picture

On the right: The same photographs fused into one by means of a prismatic apparatus. The view is taken from the inland ice across land and a cloud-covered coast





MAP - MAKING

known fjord on the east coast of Greenland. The ship sailed on, leaving us to explore the country and walk to the end of another fjord, where she was to take us off again. We had a hand-drawn sketch-map with us, whereon the outlines of the region were indicated by dotted lines, and beyond that nothing which could help us. We wandered through unknown valleys, seeking our way with the help of a compass, and encountered large rivers which could only be crossed with great difficulty. We had to leave all our gear behind in order to get down to the other fjord, and when we reached it we found that its position was quite different from that shown on our primitive map. We met the ship again some weeks later wild with enthusiasm; our experiment, full of uncertainty and risk, had been a true adventure.

The scientist of to-day is supplied by the leader of the expedition with a miraculous map of this same region. He can sit at home in his room and plan his route in detail, choose which mountain-passes he will take, and calculate accurately how long he will have to be away to get his work done, and the quantity of provisions he will need. It is almost like planning a week-end walk at home.

It will be realised what this means to the efficiency of the scientist, and to the future exploration and exploitation of the country.

CHAPTER IV

GEOLOGY

As soon as we have secured the first maps of any region, the geological research can begin. We want to find out how the land came into existence, we want to learn what kinds of rock are to be found and how they are stratified, and we must know what there is in the way of fossilised remains of the creatures and plants of the past. We want to discover what forces have given the land its appearance, what has caused the strata to lie in just the way they do, and the varieties of rock so distributed, and what has brought about the formation of mountains, fjords and valleys. These investigations are of great scientific interest, and the explanation of local phenomena contributes to the understanding of the creation of the whole globe, and the evolution of the animals and plants living on it at the present time.

This research is nowadays divided among a series of experts. The petrographer examines individual types of rock, and gives an account of how they are classified; with microscopic and chemical analyses he can see what volcanic and edaphic forces have influenced them, and given them the appearance and composition they now have. The stratigrapher and structural geologist study the actual strata and from them draw conclusions as to their relative ages and the forces which have contributed to their stratification. Herein they are helped by the

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palæontologist, who ascertains by the help of the fossilised remains what creatures and plants were living as each deposit was formed. Some of these remains make it possible to tell the age of the strata by comparing them with those of other countries. These are known as zone-fossils, and they are of special interest to the stratigrapher. But besides this the palæontologist has another very important task. In a more detailed study of individual fossils he examines the structure and appearance of the creatures of the past, and classifies them, giving them their right place in the table of evolution; and finally he is able to enlighten us as to the various lines of descent, and the relationships between the living beings that inhabit the earth to-day.

Of the other special branches of geology we can mention geomorphology, which is concerned with the question of how the surface of the earth came by its present appearance. Glacial geologists are useful here, for they specialise in the study of ice and its influence in the past and in the present. For these last the Arctic regions are of course a superb working-ground. But for all geologists it is true to say that the Arctic is an ideal field, the chief reason being that these lands were very late in freeing themselves from ice after the last great glacial period. Since then the weathering and crumbling has not been sufficient to cover the deposits with rubble; and if such loose material does form, it has a good chance usually of being washed away, since the water which carries it off comes as a rule all at once and with great force at the spring thaw. Furthermore, certain of the Arctic areas



ROCK WALL, IN EAST GREENLAND

Horizontal strata which at a later stage in the formation of the rock have been folded and twisted into strange shapes





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have undergone violent change at a late geological period (the Tertiary) during which new rock-masses have been formed, new sorts of rock have been thrown up out of the interior of the earth, and great cracks and chasms have appeared. This means that rocks of all periods are laid bare to the scientist in a unique way, and the vertical cliffs of the fjords appear like a cross-section in a geological text-book, with their horizontal or folded strata in all colours of the rainbow. In the slanting sides of valleys the same strata appear in such a way as to be easily accessible to the scientist, and here the palaeontologist can work at his ease.

It is therefore not to be wondered at, if geological research in the Arctic has brought rich rewards in all its branches. Indeed, problems have been solved here, and discoveries made, which have greatly increased our general scientific knowledge, and have been helpful in the investigation of other regions. This last fact alone leads men in all parts of the world to count on the continuance of research in the Arctic.

Our first rough knowledge of Arctic geological conditions ran parallel with the first exploration. It is true that professional geologists did not then take part, but we did get to know something of the composition of the rocks. The explorers could tell of 'folded beds', of red sandstone, or dark basalt sills; they brought specimens home, or we received the first fossils, whose appearance had attracted the eye of the traveller, though often we were given no exact particulars of where they were found. As early as 1576 Frobisher came upon some

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pieces of golden stone in Labrador which he believed to be gold, and the interest of explorers has often been aroused since then by particularly colourful or brilliant minerals.

We could not of course obtain any more thorough examination before a certain number of scientists had begun to take part in the expeditions, that is to say mainly at the end of the last century. Yet even for these, research could often only take place sporadically, according to the progress made by the cartographer. Either one could only examine a small area, separated from its surroundings and therefore difficult to understand, or else the scrutiny was superficial and incomplete; for in the difficult conditions of a sledge-journey, or indeed in the primitive circumstances as a whole, geological work often took on the nature of a reconnaissance.

These earlier attempts, often made under great difficulties, have not been wasted labour. Not only did they form the basis for present-day work, and make a more detailed scheme possible, but the results of their discoveries, often surprising, have been a most valuable guide for those who came afterwards.

Thanks to modern methods, the geologist works in very different conditions to-day. Take only the first survey of a virgin tract of country. The explorer in the time of our parents was confined to the contemporary modes of transport, such as have already been described: a rowing-boat along the coast in the summer, and in the winter a sledge either man-hauled or drawn by dogs, so that his time was taken up with everything but science.

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Perhaps he covered as much as twenty-five or thirty miles in a day, and then only had time to gain a general impression of his surroundings. The geologist of to-day gets into an aeroplane, which brings him as far in an hour as his predecessor managed in four strenuous days. And what is more important, the machine carries him so high above the mountains that the land lies beneath him like a map. The trained geologist, by looking at the shape and colour of the mountains, can make in his head a rough geological map of the district; he can determine at a glance where the edges of the strata will come most plainly through to the surface and where the dividing-lines between the different varieties of stone are most marked. In this way he knows exactly where it will be best to start the detailed examination. The aeroplane helps the geologist again when work in the coastal areas is finished, for he is usually familiar with the appearance of the different types of rock, and has learnt their age, so that a flight over inaccessible regions will enable him to gain a detailed impression of the strata, and thus fill in those areas in his geological map which would otherwise have to be left blank. In a purely practical way, the aeroplane of course means as much to the geologist as to the other scientists, since it can set him down in places which would otherwise have lain beyond his reach, and it saves him a great deal of time by carrying him quickly from place to place.

Nevertheless, when it comes to detailed investigation, the aeroplane is of no great practical use to the geologist. He likes to be in real contact with the rocks, to break off

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pieces with his hammer and take them home for closer scrutiny. And this of course is even truer of the palæontologist, who must secure his specimens and subject them to minute inspection. The geologist therefore does better to avail himself of other means of transport. The aeroplane is useful for a preliminary survey, as indirectly it helps him to secure topographical maps, and — which is perhaps even more useful — provides him with aerial photographs of the areas he works in. This last deserves perhaps a rather fuller mention, as it is a remarkable example of the efficiency of the modern expedition. While the geologist sets to work, photographs of his surroundings are taken from an aeroplane. These are developed at the air-base, and a copy is made of those pictures which are of special interest. No later than the following day, the aeroplane lands at the geologist's camp and delivers the pictures. Then, though he seems no more than an ant among these mountains, he knows his surroundings in detail, and he can apply the correct geological colours to the pictures, or use them as ground-work for his delineation of the strata; and by their help he can trace the same strata on the other side of the mountains. The aeroplane has widened his confined horizon.

But the geologist himself keeps to the ground. He has a rapid motor-boat at his disposal and modern camping equipment, and with his wireless transmitter he can summon provisions or help. If he has to make an excursion inland, the ship sets ponies ashore to carry his gear and bring his collection of heavy rocks out to the coast.

We cannot embark here on a description of the more

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scientific methods employed by geologists in their examination of the country, especially as these are not peculiar to Arctic regions. Even so it will be realised that the general organisation and technique of the present day has made the work of the field-geologist much easier. He owes to it also many labour-saving devices. He has fine aneroid barometers, which are models of modern instruments of precision, to give him his exact height above the sea. He has strong geological hammers of hard, Swedish steel, he has special instruments and prismatic compasses. His methods, however, are the same as those used in other parts of the world. As it may be of interest, though, to see how the practical prospector works in the Arctic, we shall consider the Swedish activity in East Greenland of recent years in the search for rare metals; and to get some idea of the significance of modern methods for the palaeontologist, we shall see how the interesting fossils which are brought home from the Arctic are examined at the Riksmuseum in Stockholm.

The Arctic work of the practical geologist, which consists of the examination of deposits of ore, is necessarily founded on scientific investigation and mapping. Veins of ore are confined to certain periods and certain kinds of rock. In the varied composition of Arctic lands, in which a series of strata from all possible ages goes to form the rock-masses, the scientist must first have drawn out his geological map before he can indicate to the engineer the limited areas which will be worth while investigating in detail. The petrographer or stratigrapher must already have worked the area, and the palaeontologist by the

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classification of zone-fossils, must have co-operated with them. All these purely scientific investigators will each have their value for the prospector, and they are indispensable in the later practical development of the rich resources of the earth. The area suitable for the prospector to start his work is further narrowed by other considerations—economic. The relative difficulty of access to the greater part of the Arctic, and the prices fetched at the moment by metal in the markets of the world, compared with the occurrence of ore in other more easily reached parts of the globe, would render mining unprofitable, even were the ore as plentiful as in places farther south. For this reason, it is the rarer, costlier metals, with the greatest weight-value, which we look for first in the Arctic. This means primarily the precious metals: gold, silver and platinum; and to these are added other rare elements which, in recent years particularly, have become so important in modern industry, either in themselves, or because their admixture with other metals gives these special properties. Of this class we may mention tungsten, molybdenum, titanium and vanadium. Many of these materials are often to be found in veins with the precious metals, especially as sulphides and other such chemical combinations.

Through research in East Greenland up to the year 1932, it had become possible to estimate the position of such veins. But a difficulty arose in the fact that the very minerals which go to make up these veins are most subject to weathering, and are more easily broken down than the rock which contains them. Therefore in the

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places accessible for examination, the ground is often covered with loose, broken-off material, and we cannot simply knock a piece off and take it home for a closer inspection. On the other hand, from the appearance of this material, and with the help of the coloured salt deposits at the springs, left by water which had passed through deeper layers, the geologists could see that somewhere or another within a limited area something of interest was to be found, though they were not in a position to locate the veins more accurately.

Here the modern prospector and his apparatus came to their aid. The method introduced into East Greenland in 1932 was used elsewhere by Swedish geologists, and the instruments set ashore on the East Greenland coast were the property of the Swedish Prospecting Company [Svenska Malmlefningsaktiebolag], whose engineers had used them last in Africa. They were now dragged up by Iceland ponies to the district then being examined, and unpacked in the Arctic wilderness.

Even for the initiated, trained engineer, who is accustomed to handling these instruments, the modern method of prospecting for minerals is involved and difficult. I cannot therefore give an exhaustive description of the working of this newest branch of modern Arctic exploration, but I will try to give a glimpse of how these investigations are carried out, and how work progressed up in East Greenland in the summer of 1932.

Electric ore-prospecting is based on the fact that different kinds of rock vary in their propensity for conducting electric and magnetic currents. One of the methods of

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procedure is briefly as follows: along the surface of the ground is laid an insulated electric wire, connected at both ends with the earth. To this wire we attach a little A.C. generator, which sends a current along it. The current passes into the ground and returns to the other end of the wire. Round this circuit a field of electric force is set up, the strength and direction of which varies according to certain laws. The existence of metal or other conducting materials causes deviations in this field. The prospector's task is now, with the help of apparatus which varies in individual cases, to reckon and record on an ordinary, detailed topographical map, the place of the field, and compare this with a theoretical chart. The experienced geologist can establish from these variations not only the position of the bed of ore, but also its depth beneath the surface of the earth.

For the uninitiated visitor, the scene of action was an incomprehensible muddle. In the middle stood the little petrol-engine connected with the dynamo, and its explosions resounded day and night between the mountains. The area to be tested was marked out by countless little cairns. Long cables were unrolled all over the ground, and in the middle of all this wandered the prospector. He held in his hand a sort of frame aerial suspended gyroscopically, so that it could be turned in all directions. On his back he carried an electric apparatus that looked more like a wireless receiving-set than anything else. On his head were earphones. The principle of his prospecting was that he brought his aerial to certain fixed points, and turned it until he heard a particular

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note in his earphones. Then he took a few readings and dictated some figures to his assistant; and what these figures meant hardly anyone but himself understood.

But the result of many weeks of this work was a map covered with a mass of different lines, which in the end made it possible for him to give some account of the nature of what lay beneath the surface of the ground.

When the mining-engineer has located the bed of ore, the next task is to find the ore to get it analysed, and discover whether it really contains valuable minerals, and if so in how great a quantity. Getting at the ore in the first place is not easy in these regions. There is no great body of workers at hand, and to move even a few cubic yards of earth here, where the ground is either frozen immediately under the surface, or so mixed with water that it keeps falling in, is a matter of great difficulty. Props for shoring-up must be brought from the south. If the ore lies at any distance from the coast, the problem of transport is a considerable one. So it is no small undertaking to start such research as a branch of an ordinary expedition. Nevertheless this question too, which is so essential to our knowledge of the resources of the Arctic lands, comes under the heading of Arctic exploration, and we must describe something of such an investigation, choosing once more an example from the Scandinavian expedition to East Greenland.

The prospecting engineers had found a place which they decided to examine more closely, and in the summer of 1933 the 'Gustav Holm' set the mining party ashore. It was the biggest of all the parties in the expedi-

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tion and was composed of technicians, scientists, miners and excavators. Enormous masses of material were brought ashore. Half a score of Iceland ponies carried it inland, going regularly between the coast and the mining-camp the whole summer, first with camping equipment, stores and the most important instruments, then with pit-props and cases of dynamite, tools and more provisions.

Inland a little town of tents sprang up. The miners dug a shaft, and soon rock was struck. But it was not enough to examine the types of rock here, for the outside of an ore-body can be very different from the lower levels. The digging had to proceed by means of drills and dynamite. At regular intervals the hollow boom of blasting echoed and re-echoed. The men were experienced and understood their job, being from the Grängesberg and Falu mines in Sweden.

The mining-engineer received from time to time samples of the ore from the pit, and these were immediately examined, for attached to the camp was an up-to-date laboratory where analyses could be made. Here under a powerful stamp the rock was pulverised. To test for gold it was necessary to melt the crushed rock. In the middle of the laboratory a smelting-furnace had been erected, and to heat it the chemist made use of a petrol blow-lamp of a generous size. The flame was introduced through an opening at the base of the oven, and twisted upwards in a hissing spiral enveloping the crucible. Within the furnace the temperature rose to over 1200° centigrade so that all but the chemist, who was used to

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the work, and wore only a pair of shorts, hastily disappeared from the little laboratory.

Full advantage must be taken of the short Arctic summer. Work goes on day and night in the little mine; from the forge is heard the blows of hammer on anvil, and in the laboratory the blow-lamp hisses unceasingly. A few short weeks and all is over. Camp is struck and the men make their way to the coast to board the ship. Soon afterwards the snow has hidden the last signs of our activity, and the land appears once more as it was before man began his hunt for wealth in this remote region.

It is a very different hunt which is pursued by the palaeontologist. His big game is that of a vanished world. This vanished world, these lands of an earlier age, had an appearance very different from the Arctic coasts of to-day. The high mountains of sandstone and schist which now rise more than 3,500 feet above the surface of the sea, were formed in the ocean depths. From massifs which have now almost entirely disappeared, mighty rivers carried down the loose material to the sea. The finest was taken farthest, and turned into clayey schist; nearer the coast the sand sank to the bottom, and close in-shore the coarse sand in which the beat of the waves set those marks still visible to-day, hardened into sandstone. In the larger lakes, too, between the mountains which heaved themselves up under continued volcanic pressure, and were constantly worn away by the action of wind and water, sand and clay were deposited, amongst lava and ash which bear witness to volcanic activity.

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The largest of these deposits were formed at a remote period, the Devonian, which of recent years has been thoroughly investigated by Swedish palæontologists. The Swedish Professor Säve Söderbergh gives us a picture of the land and the life upon it in former times, when the climate was entirely different from that now prevailing in the Arctic.

In the rivers and lakes there lived creatures, primitive in form, yet distinctive, consisting mostly of different fish-like species, but including also primitive quadrupeds. Different types of armoured sharks, all with the head and the fore part of the body covered with the characteristic plates of bone, and with the pectoral fins greatly reduced and altered in shape, kept mostly to the mouths of the rivers, and lived on algæ and small invertebrates. *Crossopterygæ*, big fish of prey having many savage teeth, seem to have been good swimmers, and were apparently the armoured sharks' worst enemies. On the shores lived primitive four-legged creatures, the *stegocephalæ*, with heavy, entirely armoured heads and presumably very clumsy bodies and weak limbs. A few dipnoids and kindred long-nosed species swam about in the deeper water.

All this world of creatures lived in constant danger, threatened by volcanic disaster and landslides from the surrounding mountains which caused damming or silting up of the rivers, lakes and stretches of coast on which their lives depended. Added to this were the movements of the earth's crust which together with the crumbling of the rocks and the accompanying deposits of mud and sand, in time altered the course of the rivers and dried out the lakes. In this way large numbers of fish met with sudden death. It sometimes hap-

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pened that a certain stretch of a watercourse ran dry or was silted up, so that the fish died, and rotted where they lay at great heights in the mountains. Later perhaps this area would be flooded by a river which deposited silt and sand on the skeletons of the dead creatures, which were thus preserved, with the bony plates in a natural position.

Since these catastrophes several million years have passed. Sand and mud have hardened, compressed by the movements of the earth's crust and by more recent deposits. The old deposits left by rivers and lakes have by movement and erosion cut new valleys through the great strata of sandstone and marl. In the sides of these valleys and at the bottom of the fjords we can study a cross-section of a whole series of successive deposits from the Devonian period, in which each stratum or series of strata in the rock bears witness to the long extinct animal-world which we have here briefly described.¹

These fossilised remains, then, form the big game of the palaeontologist. Throughout the summer he ransacks the strata, and rucksack after rucksack of heavy stones containing fossils is dragged into camp, labelled, and packed in boxes. Strings of pack-ponies carry the heavy load from the camp through the mountains to the coast, where it is taken on board.

Most of the fossils of the Devonian period collected in the Arctic end up in the Stockholm Riksmuseum, where the real examination takes place. On the spot itself there is neither time nor opportunity for this, as every hour

¹ From Professor Söderbergh's contribution to *Med Treaareks-peditionen til Christian X's Land*, Gyldendal, 1937.

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of the short Arctic summer must be used for collecting the specimens which are often so embedded in the hard sandstone that only a corner sticks out to tell the collector that this block contains something of interest. The first difficult work in the laboratory is therefore that of detaching the specimen. Formerly a little hammer and chisel were used for this, but to obtain quicker and more accurate results Professor Stensjö has replaced these hand-tools by small, fine chisels which are set in rapid motion by an electric machine — the same as that used by dentists for their drills. At first it was hard to procure the sharp-pointed chisels, which had to be of very hard metal, until someone had the idea of using old gramophone needles. To obtain a large enough quantity of these needles, which quickly wore down, the research-workers became regular customers of the Broadcasting Company, and as soon as a needle has played the latest Broadway Melody for the Swedish people, it is sent out to the Riksmuseum, where it extracts 1,300-million-year-old fossils for the scientists.

The preparation of these specimens nevertheless takes up a great deal of time. It must be done with the greatest care; grain after grain of sand is chiselled out of the hard stone, and for greater accuracy the worker looks at the object he is engaged upon through a binocular microscope. When at last the head-shell of the fish, or whatever it may be, lies clear and plain on the surface of the stone, it is passed on to the specialist who sets about the scientific investigation. To facilitate survey and comparison it is photographed at the same time. The camera



DETACHING A FOSSIL FROM THE ROCK

This is done with the help of electrically-driven chisels. Through his binocular microscope the scientist scrutinises the stone which is illuminated by strong projectors



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used here is no ordinary one; it takes up a whole room. The stone is immersed in a liquid having special properties of refraction, which cause the structure of the fossil to appear very plainly. Big projectors throw a powerful light on it, and over the great basin in which the specimen is immersed, is suspended a huge camera, which is operated from the top of a ladder. The photographs are used in further study, and with their help the reconstruction of the head-shell, or of the whole animal, is possible.

The great interest of these Devonian fossils lies not only in the nature of individual species of animal, but also in their kinship with one another and with creatures of earlier and later geological periods. The study of evolution teaches us that all living beings are related to one another, and that there has been development from lower to higher forms. A more exact knowledge of this successive progress can be obtained through a branch of science known as comparative anatomy. Students of this subject examine individual organs or bones in various creatures, and, by comparing them, form an idea of near or distant relationship. The evolution of the visceral skeleton of fish is of common knowledge, and a vestige of it is found all the way up the scale to man, though in him it is no more than a pitiful little bony structure at the root of the tongue. Yet we find in the human foetus clear indications that we are related to creatures which breathe through gills. From this it should not be concluded that we are descended from fishes, or from apes. The relationship is better regarded as a genealogical tree, of which

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fish, toads, insects, etc., are different branches of the original stem. What we see of this tree to-day is only its outermost branches, its twigs and leaves; but hidden by this close foliage, twigs run into branches and branches into greater branches, until we reach the primeval common stem of all.

But it is towards the understanding of just these branches, which indicate the relationship between creatures now extant, that the Devonian fossils can help us. For some of these 'fish', well-preserved through millions of years in the hard stone, were the basic types from which numberless branches of the vertebrates have developed. One thing in particular is intensely interesting, and relates to the question how and when creatures first came on land. The earliest beings were entirely confined to the sea: limbless things whose only evidence of a vertebrate nature was a single cord along the back. The evolving of limbs with which to move about on shore, and of quite different breathing apparatus, was hitherto one of the most obscure points in the history of vertebrates. It was on account of this that the discoveries in East Greenland awoke such general interest, and the tale of the 'four-legged-fish' was told in the newspapers of the world.

The 'four-legged-fish' is a bad name for an extinct, particularly primitive group of creatures called stegocephalæ of which individual remains had been found in deposits dating from the coal age. Now in Greenland they were found in the far older Devonian period, so that we had even more primitive forms, which would be a

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greater help in throwing a bridge between fish and quadrupeds. The results of the investigations at Professor Stensjö's institute — investigations which are incidentally still in progress — were that although many points remained obscure, a more thorough understanding was reached of the relationships between many groups of primitive vertebrates from earlier ages. And hereby light was thrown also on our own dim past.

The Devonian fossils represent some of the oldest known vertebrate remains. When we come to more recent geological periods, we find more highly-specialised varieties. A great collection of fish-fossils from the Triassic age, for instance, has been brought back from the Arctic, chiefly Greenland and Spitzbergen. These specimens at first glance greatly resemble the common herring or plaice. They are often found in finer material than the hard, coarse Devonian sandstone, and they are often extraordinarily beautiful and well-preserved. They can therefore be studied in far greater detail than the Devonian fossils. In this study at Professor Stensjö's institute a most interesting method is employed, called after its inventor the Solla Grinding Method. In this the bones are not detached by means of dentists' machines. Instead, a stone is chosen in which whole bones — a skull, for instance — is embedded, and it is now worn away against a fine slipstone, so that a polished surface is obtained. At the moment the stone has been rubbed down enough to show the first hint of the skull, the polishing stops and the stone is photographed by a microphotographic camera. Once more a fraction of the whole

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surface is ground away — perhaps a millimetre — and another picture taken. And so the process goes on, layer after layer, farther and farther into the skull, until a whole series of cross-sectional photographs of the skull is obtained, in which not only the outline of the bones can be studied, but also all the internal cavities, and passages which once held nerves, veins, etc.

The next step in the examination is to make thin wax plates from the microphotographs. On each of these plates the bones are marked in one colour, and the nerve and vein-passages in others. And when all these wax plates are put together in their right order, we have a reconstruction of the skull, in which red veins and blue nerves twist in and out. We have an accurate reproduction of all the soft parts that rotted away millions of years ago, and were replaced by the fine mud which afterwards hardened into stone.

The method of comparative anatomy can thus be used not only in the case of hard, petrified pieces of bone, but also for the soft, internal organs, and we can get an exact knowledge of the whole structure of these prehistoric creatures, the shape and size of their brains, and their nervous and venous systems.

The conclusions arrived at, with the help of Arctic discoveries, on the subject of the inter-relationship of the vertebrates are too complex to be mentioned here, but Professor Söderbergh, in a chapter of the above-mentioned book, recently gave a clear survey of these questions, accompanied by a presentation of the genealogical tree of the vertebrates, which, according to the most

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recent discoveries, may be supposed to conform fairly nearly to the truth. Professor Söderbergh gives a more detailed account also of the palæontological work and methods, and he concludes his description of the Solla Grinding Method thus:

We find here evidence of the importance of modern technique in scientific research. The results in the realm of paleontology, of which we have already taken a brief survey, and which fundamentally alter our conception of the vertebrate group, have been secured thanks to the vision of the leaders of an expedition. They realised the importance of employing experts in a most exacting task, and have stuck at nothing in providing them with the best possible working-conditions in the laboratory, where all available modern equipment and materials were to hand.

CHAPTER V

BIOLOGY

Towards the end of the year, when the winter darkness falls over Greenland, the great majority of the birds, which throughout the summer have filled fjords and coast with teeming life, begin to gather in great flocks and make their way south to lighter, warmer places.

Among the few which do not abandon the Arctic home where they have been born and bred, is the gallinaceous bird, the Ptarmigan. It puts on its white winter plumage, and prepares to take up the struggle.

During the summer it has led a pleasant life among the fjords. Surrounded by flowers and berries of all sorts, it has been able to be particular in its diet, and the whole summer it has eaten only one kind of food, the bulbils of the Alpine Bindweed (*Polygonum viviparum*). This plant grows best on the slopes of the fjords, which are damp because the snow stays here longest. But it is in just these places that the snow lies first and deepest, swept in by the early autumn gales. And one day the Ptarmigan sees the sides of the fjords covered with a thicker layer than it can manage. Instinct, or whatever one may call understanding in animals, tells it what it must do. It finds its way out to the coast and the big flat plains which fringe the Arctic Ocean.

Here the northerly winter gales sweep down the coast, and blow the plains free of snow. Only a few

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plants can survive without the protection of snow during the worst time of the year. These plants, Purple Saxifrage (*Saxifraga oppositifolia*) and white Dryas (*Dryas octopetala*), and above all the Arctic willow (*Salix*), are the Ptarmigan's only food. On the most constantly windswept flats, only the Purple Saxifrage can survive, and on the days of the worst and heaviest falls of snow this is what the Ptarmigan feeds on.

In the meantime the light has grown fainter and fainter. The cold is biting, and there are fewer and fewer hours during which the bird can see the plants. In the central part of East Greenland the feeble noon light of midwinter lasts only two hours, so that the hardy little bird has to hurry. At that time of year, when the light is at its strongest, one can walk right amongst a flock of them, and they will not fly up — only move to one side, snapping a couple of beakfuls on the way. And if they are to find enough food in those two hours they must not be too particular. They can no longer do as they did earlier in the winter, and choose the topmost buds of the willow. They must gulp down their food, and, not satisfied with the buds, they grab a whole branch. The sharp, scissor-beak cuts and cuts at tremendous speed, and the bird swallows about eighty good-sized mouthfuls a minute.

This winter food has a high fat-content, which is of course very acceptable, as the Ptarmigan, like other beings, needs fat in cold weather, when inner combustion is considerable, and when a layer of fat under the skin is needed as a protection against the cold. But in the

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spring the Ptarmigan begins to suffer from lack of albumen and it must have plenty of protein, particularly as it will soon be laying eggs. It begins therefore to seek for the stem-tubers of the *Polygonum*, or the fertile spikes of the rare Horsetail (*Equisetum* sp.) which are rich in albumen. Soon afterwards the snow melts, and once more it can make its way in to the bulbils of *Polygonum* in the fjords, and here the eggs are laid.

We have here a little biological sketch of one of the varieties of Arctic birds. We see how things fit in, and how the Ptarmigan has learnt to adapt itself to its circumstances. How do we know these facts? Such knowledge seems very simple and straightforward, but think of the study it represents. One must know the country and the climate, and understand thoroughly the conditions of vegetation with regard to snow and prevailing winds. One must have studied the habits of the Ptarmigan at the different times of the year, and examined the contents of its stomach, or rather crop, at all hours of the day. So that behind this little biological sketch of the Ptarmigan lie long years of study and investigation which have been summed up in an admirable thesis by the Danish biologist Paul Gelting. He has measured accurately the depth of the snow and its duration in different places, he has studied the proportionate grouping of the plants, he has carefully counted particles of food in the bird's crop and has measured and weighed each fragment. He has made graphs of all these things, and chemically analysed portions of plants to find their food value. Only after this circumstantial investigation

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can he draw the conclusions which give us an insight into the living conditions of the Ptarmigan.

Modern exploration alone could have made such investigation possible. Only the big winter stations with their laboratories and electric light, and the good, secure working-conditions for the trained expert, have made it possible for us to enter so thoroughly into Arctic life. Knowledge of the biology of animals and plants has made a rapid advance in recent times. Only a few years ago the Arctic traveller was confronted with many riddles which are now being solved one by one. The winter stations in the wilderness make it possible for the scientist to undertake minute analyses all the year round. Modern means of transport carry him far and wide, and modern cameras and cinematographs with telephoto lenses follow the wild creatures into their natural surroundings. Our knowledge of their manner of living and their adaptation to extreme circumstances has advanced. But I do not propose to deal here with the conclusions arrived at by the modern zoologist. My task is primarily to explain the *methods* employed in Arctic biology.

Thanks to the efficiency of the modern expedition the Arctic biologist can now use purely scientific methods even in regions which before were regarded as almost inaccessible, and where one could remain for only a short time in primitive conditions. The biologist can study his problems seriously and thoroughly; he can count, measure and weigh, and, while enjoying personal safety, he can collect a large amount of experimental material.

The botanist literally counts the plants. In the sum-

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mer a motor-boat or an aeroplane brings him quickly to the place he has chosen for his investigation, and thanks to these methods of travel he has time to visit the most widely differing places. According to the newest methods of phytogeography, he makes statistical investigations of plant families, and obtains an accurate knowledge of their respective proportions as compared with other regions.

The botanist measures each species. He measures the depth of the snow day by day all the year round. With his modern instruments he can determine the conditions under which the plants below are living. One of his instruments is the thermograph, an amazingly ingenious invention, of which the part sensitive to temperature, the thermo-element, is inserted among the leaves of the plants. From this there are leads up into a little air-tight box where, by means of clockwork, the temperature is automatically registered on a long strip of paper wound round a drum. All the botanist has to do is to change the paper once a week, and wind up the clock. Yet in this way he collects interesting material in the course of the year. The temperature is of course not the same down on the surface of the ground among the leaves of the plants as it is at the height at which we humans move about, and at which the meteorologists record the temperature. The plants shelter each other, and the sunshine on the dark surfaces, and the influence of the soil, all these factors affect the temperature in which the plants live, and is of the greatest importance in understanding their conditions.

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Another of the botanist's instruments is the light-meter, which we know in photography. This shows him the difference between the brightness of the light on northern and southern slopes, and with this he measures the variation in the strength of it throughout the twenty-four hours, in all seasons. Light is of supreme importance to the thriving of plants, and in Arctic regions the conditions are peculiar. There is the midnight sun, which enables plants to benefit by the light twenty-four hours of every day in summer, and they have a continuous period of growth, in contrast to the plants in lower latitudes, which have an enforced period of rest every night. To make up for this they have a long period of cold and darkness, during which all life is suspended. Also, since the sun hangs low in the sky all through the summer, the aspect, that is to say the slope of the ground in relation to the sun, is of great importance. These questions can only be answered by means of accurate measurements with modern instruments.

The modern Arctic botanist has other instruments at his disposal, but they are too complicated for us to do more than mention them. He has an instrument for measuring the amount of acidity in the soil, which tells him exactly how much lime or how much humic acid there is on the surface of the ground: facts which are of great importance to plants, and are often the cause of the varied appearance of the vegetation. He has apparatus for analysing the amount of nourishment taken in by the plant, and for many other things.

A well-known instrument, old in the service of re-



top left: THE YELLOW ARCTIC POPPY

bottom left: THE COMMON HAREBELL, WEIGHED DOWN BY
TINY DEWDROPS. THE PHOTOGRAPH WAS TAKEN
ABOUT 560 MILES NORTH OF THE ARCTIC CIRCLE

top right: THE FRINGED SANDWORT



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search, is the balance, but only recently have expedition methods made it possible to take really accurate measurements in the Arctic. In his laboratory at the winter-station, the biologist now has his balance set up in a glass case, and with its help the growth of plants is measured, and the soil they grow in is also measured, to get an idea of its dampness. This last factor is a decisive one, because humidity in the Arctic regions is subject to quite different variations from those in home latitudes. In winter the whole of the surface of the soil is frozen hard. In the spring the top layer melts at the same time as the snow, thus causing floods which cannot sink away through the earth as in our country, because the ground is nearly always frozen to a certain depth. The surface becomes therefore a swampy or loamy morass, and if it is on a slope, the whole mass of mud and clay may begin to slide slowly downwards. But when the thaw is over, it happens constantly, in these regions which often have a continental summer climate without much rain, that the surface in exposed places dries out entirely, and gets as hard as stone. It is clear that these peculiar conditions of irrigation have an enormous effect on the growth of vegetation, and that plants must adapt themselves to it in one way or another.

It would take us too long to examine more closely the different modern methods of which biologists avail themselves in the Arctic. But just to give an example of how many-sided and exact their investigations are at the present time, and what interesting results can be arrived at, we can look for a moment at a single aspect of bio-

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logical research. It will show how an apparently quite specialised study may come to throw light on problems of a more comprehensive and general character.

It has been found that the surface of the ground in the Arctic regions — as elsewhere — harbours considerable microscopic animal life. In the earth itself, but particularly in mosses and lichens and amongst rotting vegetation, dead leaves, etc., there are millions of minute creatures, belonging to the lowest groups of articulata: Spring-tails (*Collembola*), Mites, and others. But how to isolate these and study them was a question which remained unanswered until the Italian zoologist Berlèse had an ingenious idea. He gathered the damp remains of moss and plants and put them into an ordinary funnel. This funnel was fixed to a stand in a warm room, and under it he set a little jar of alcohol. As the bits of vegetation at the top, in the mouth of the funnel, dried off under the influence of the warm air of the room, the tiny creatures, disliking this, crept lower into the damper layer underneath. In time, they all collected at the bottom of the funnel, and at last slipped through the tube into the jar of spirit. In this way the zoologist separated all his little creatures from their surroundings without the slightest trouble. And on peeping through the microscope at the contents of the jar, he was rewarded by a remarkable sight. Hundreds of tiny animals of all imaginable shapes, with jointed limbs and strange biting or sucking organs, were gathered together in the drop of spirit under the microscope.

Arctic zoologists were among the first to adopt Ber-

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lése's idea, and the 'Berlése Funnel' as the apparatus is now called, has been used in many parts of the Arctic. It has given amazing results. The Arctic soil, covered for many months by snow which in the winter has a temperature of many degrees below freezing point, harbours vast quantities of these minute beings. The description of the different kinds would fill many volumes. Many of these creatures are the same as are to be found farther south; many again have hitherto been known to exist only in the Arctic regions. Experiments have been made which show that they can keep alive for months at a time even when frozen in a lump of ice; and it is believed that their eggs so embedded will keep for years. Then one day, when the ice melts, they hatch out and begin their modest life in the darkness among the withered leaves.

Of what interest are these little creatures? There is naturally always scientific interest in the study of yet another of the many aspects of life, and therefore the systematic zoologist describes the different varieties, draws and photographs them, and classifies them. But there is more to it than this. They have their place in the great Arctic scheme; they live on rotting vegetation, they help to break it down and transform it into nourishment for new growth. They themselves serve as food for other organisms; therefore they must be studied as a link in the chain. Their number in a given square surface measurement is also studied, in differing vegetation; on Arctic moorland, in mountain country or the salt marshes by the shore.

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Even more far-reaching conclusions may be drawn by the discovery of just which species are to be found in the Arctic. Sigurd Thor, a Norwegian scientist, took the Berl  se Funnel up to Spitzbergen, and there found that there were perhaps a thousand creatures to the square metre. He wondered how they could have reached Spitzbergen. They can hardly move, and are wingless, so that they could not have flown there. And then he observed that the kinds he found belonged chiefly to the lowest, least differentiated families within the different groups, while the more developed ones, so common in the north of Norway, seemed to be entirely missing. From this and other indications he concludes that these creatures have existed in Spitzbergen for a very long time. Originally the same fauna inhabited both Spitzbergen and northern Europe, but then Spitzbergen became isolated, and only the original species are to be found there while the creatures in more favourable conditions farther south have evolved into superior types. From that, Thor goes on to consider the question of the connection which, it is assumed from Nansen's and Wegener's theories, once existed between Europe and the Arctic islands, and can add his contribution to the clearing up of these problems, which are of such great interest to all engaged in research among the plants and animals now isolated in the Arctic regions. We see now how an investigation, which at the first glance may seem quite a specialised one, takes its place within the great whole, and throws light on questions which perhaps seem entirely unconnected with the individual problem dealt with.

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How animals and plants arrived in the Arctic at all is a question which just at this time is especially occupying the minds of biologists. Did they come recently, or have they been able to maintain their existence there for millions of years? Were they able to survive the great glacial period when ice extended much farther than it does now, and covered a great part of northern Europe? Scientists of widely different lines of research are now spending much of their time in the Arctic in trying to solve this problem.

The question seems most easily answered by considering the birds, for we know that they can fly long distances, and we see how they leave these regions every autumn and seek the south. But how far do they fly, and where do they live in winter?

While we have a comparatively thorough knowledge of the general habits of these birds, and are familiar with their nests and the conditions in which the young are reared, there are surprisingly few zoologists who can recognise a bird in flight, and it is with its very nature as a flying creature that the most interesting problems are connected, only a few of which have been examined and explained. Until the middle of the nineteenth century the knowledge of these things had not progressed much since Aristotle put forward his theories about the migration of birds. Individual scientists still held to the theory of the swallows' winter quarters under water, in fens and other places impossible to investigate.

Mortensen, a Dane, introduced positive methods of research. He marked the birds with a ring round one

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leg, and on this ring was stamped a serial number, and an address to which the huntsmen who later might bring down the bird could send it, with particulars as to where the bird met its death. The chances of the recapture of the different species varies from fractions per thousand to 60 or 70 per cent among the large birds of prey. Many more observations are still required, and as far as the Arctic is concerned, it was not until recent years that any results were obtained. But the results are often surprising. For instance, the latest American tests show that the Arctic Tern may travel as much as 21,000 miles in a year.

The Arctic Tern breeds round the North Pole, and while it has been observed in winter in the South Atlantic, bordering on the Antarctic, it is almost unknown along the shores of Central America and the United States. On the other hand it may be seen in large numbers in August between Newfoundland and Iceland. Marked terns from Labrador have been caught in France, in equatorial West Africa and near the Cape. From this it may be assumed that the flight follows the west coast of the old world as far as the Equator, and from there partly along South-West Africa, and partly South-East America to the Antarctic. One particular tern was marked as a downy fledgling in Labrador, and was caught three months later in Natal, on the south-east coast of Africa, after a journey of at least 7,500 miles, possibly nearer 8,000, in less than three months.

Why the birds migrate is a problem which is difficult to solve. Cold, lack of food, and darkness can explain

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why birds leave the Arctic in the winter — but why do they return there, when they can stay only three months? Perhaps a general survey of the conditions which the glacial periods have imposed on animal life and the growth of plants, combined with biological research, will lead to the establishing of the chief reasons for the migration. In the meantime we simply register the fact, with the help of the rings; and it may be that knowledge of the flight itself may help to explain the reason for it.

The chief task which all biologists in the Arctic have in common, is to discover how the different organisms have adapted themselves to these extreme conditions. How, for instance, the individual plant multiplies by making the most of the short summer, and prepares its flowers in the autumn, so that as soon as the light appears again in the spring these flowers are ready to unfold and absorb it. How it puts its whole strength into speedy and effective seeding: an effort which it must often save up for many years. How an animal prepares for the long winter, how the Musk-ox and the Fox find food, how the Bear hibernates and in the shelter of the snow brings forth its young ones, and how the birds seek the south.

But above all our aim must be to understand how all these individual facts make up the great whole — how plants and animals benefit by each other, how nature's household accounts are balanced, and how each link fits into the others in miraculous adjustment to the workings of Arctic evolution.

Just now, particularly, this research which everyone is engaged upon is of the greatest possible interest, and

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everything must be done to carry it through as rapidly as possible. For it cannot be denied that the activity which man is already displaying, and which will increase in the course of the next few years, is bound to upset this equilibrium. Animals and plants have through hundreds of generations been trained to endure great cold, to survive the long polar night and to arm themselves against their natural enemies, so that individual species can balance one another. But against man and his ways they cannot arm themselves, and they come off worst in the encounter. Man advances over this finely-balanced scheme of things like a great steam-roller, and crushes it. In the Arctic plant-communities strange growths spring up, brought from other regions in the form of seeds. In the West Greenland colonies we find almost the same weeds as in our own home districts, and in East Greenland we can watch the growth of Icelandic grass where the hay for the ponies of our expeditions was brought ashore. From the winter-stations, tracks radiate in all directions, and the vegetation is worn away and regenerates itself very slowly. As far north as the 75th latitude I have found near a hunting-hut a species of grass which was brought there from Norway, and which undoubtedly hybridizes with the Greenland varieties.

The case of the animals, of course, is even worse. The fashions in European capitals demand fox-furs. Eskimo and European hunters vie with one another in satisfying this demand. With their modern weapons they manage to comb whole districts bare of Arctic foxes. No animal can withstand the poison-trap. Strychnine is put into

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dead birds destined as bait for the fox, and causes the creature to die in terrible pain. The dead fox may then become food for other beasts, and the bodies of ravens strew the coasts. In East Greenland we found the carcases of many bears, which without doubt had fallen victims to strychnine.

The best defence of the little Arctic Hare was once its great speed when running. But a rifle-shot can catch up with it. And for another reason too we have found many dead hares in East Greenland. Certain biologists think that they fell victims to some strange infection brought over from Iceland in pony-fodder. The giant of the polar seas, the Walrus, was common in the Arctic until a few years ago. We know Alwin Pedersen's magnificent pictures of the great colonies of peacefully sleeping Walruses. In East Greenland we hardly ever see them now. Many have been shot, and they do not breed quickly; others have fled. Let us hope that they have found a refuge farther north where they will be safe — until we follow them.

The most remarkable of all the Arctic creatures is the Musk-ox. It is a survival of a breed which in the ice-age was to be found much farther south. Within historical memory, Musk-oxen were widely scattered over large parts of North America; and from year to year we can follow the decrease in their numbers. The Musk-ox is one of the last surviving animals from the mammoth-period. They have adapted themselves in a unique way to the conditions in the very farthest north. Their close, woolly coat keeps out the cold, and they can get through

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the winter with the minimum of food. Their natural enemies are few. In defending themselves against the Polar Wolf, they have learnt how to form a circle with the calves and young ones in the middle. The bulls form a ring round them with their horns outwards, ready to put up a violent resistance to the approaching enemy. It is a moving thing to see such a herd encountering humans. Men can approach the peacefully grazing beasts, which feel safe and at home in the Arctic surroundings and at first show no fear of the newly-arrived beings; then they grow uneasy and resort to their only and hitherto unconquered manner of defence: they form their circle. What good is that against a modern rifle? Immovable they stand there, and see their companions fall at their sides; but they meet death calmly. They have no thought of flight. They give in to the incomprehensible, to the enemy against whom the experience of generations has taught them no defence.

We cannot arrest civilisation. Man pays homage to functionalism in the form he has himself created. The preservation of nature is a question of financial policy, and in no case can it ever produce anything but a sort of zoological garden, a substitute for wild life. Modern methods cannot run in double harness with the lovelier functionalism of the undisturbed Arctic. Nevertheless the biologists of our time should take the fullest advantage of these methods in their research, so that we may at any rate be in a position to leave to coming generations a complete and satisfactory picture of what once was.

CHAPTER VI

MARINE RESEARCH

Of the area enclosed by the Arctic Circle only two-fifths is land. Round the Pole itself lies the Polar Basin which is connected with more southerly seas by a series of channels varying in size. The broadest of these lies between Greenland and Europe. The Bering Strait, connecting the Polar Basin with the Pacific, is quite narrow, and so are the Sounds between the North Canadian islands which, with Baffin Bay and Davis Strait, connect the Basin with the Atlantic. Another characteristic of the lands round the Pole is that their coasts are strongly indented, so that not only do numbers of islands, large and small, result, but deep fjords cut into the mainland.

These seas and fjords represent some of the richest resources of the Arctic. The number of animals useful to man which inhabited these regions was the first thing that drew our forefathers' interest to the North, after they had ceased to use the straits as a channel to the distant Orient. The old whalers and seal-hunters soon gained a detailed knowledge of the Arctic water-ways; they learned in what areas they should seek their catch; they made observations about wind and weather, and they became skilled in understanding the ice-drift which was such a danger to their ships but which at the same time formed the best hunting-grounds.

Unfortunately, posterity could profit little by these

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valuable experiences. The old sea-captains of the Polar Seas knew how to keep their knowledge to themselves. The secrets of the trade brought them in their earnings, and when they grew old they bequeathed the rich experience of many years to single successors, usually within the family. So that even now to-day when we sail into a fjord which we believe to have been hitherto unknown, we may find traces showing that it was familiar to the old Ice Sea people. In old deserted Eskimo ruins thereabouts we find glass beads and bits of Dutch pottery, proving that, unknown to those who came after, seamen were once in contact with the now extinct tribes.

It is therefore mainly since the beginning of scientific research that we have gained a more accurate knowledge of Arctic waters. The research went on not only during the voyages to and from the coasts; special marine-research expeditions were also sent out. This branch of science has of recent years undergone the same development as the others, and our survey cannot be complete without some mention of it and its methods and theories, of the results already gained and those which may be hoped for in the future.

The first question to be tackled is that of the extent of the Arctic seas, not only in fixing the coastal boundaries, which nowadays is done chiefly by mapping the land, but also in registering their varying depths. To chart the sea-bed is important because for one thing knowledge of rocks and shoals lessens their danger for shipping, and accurate charting of the bottom makes navigation easier, since a sounding in a known channel can be a check on

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astronomical bearings. But the knowledge of the seabed is important in many other ways. It has a practical interest for fishermen, since most fish frequent places of a particular depth; one has only to remember the North Sea or the Newfoundland Banks. It has a theoretical interest for the geologist, who can follow the continuation of massifs beneath the surface of the sea, and thus establish the geological connection between different regions.

Seafarers of earlier days used for their underwater exploring a lead which was sent to the bottom at the end of a thin, strong line. This had knots or marks at intervals along it, from which one could see how many fathoms were out. In deep waters the task was harder, for here heavy hemp lines had to be used. These took up a lot of room and even then could not always bear their own weight. It was a real step forward when in 1876 metal lines came into use. Strong steel wire, of exactly the same sort as is used in an ordinary piano, was produced; it could be manufactured in any length, and the greatest depths anywhere in the world are sounded in this way. The measurement itself is made by running the line over a wheel attached to a counting mechanism known as a meter-wheel. Improvements were made by constructing special sounding machines, driven by a motor or by electricity.

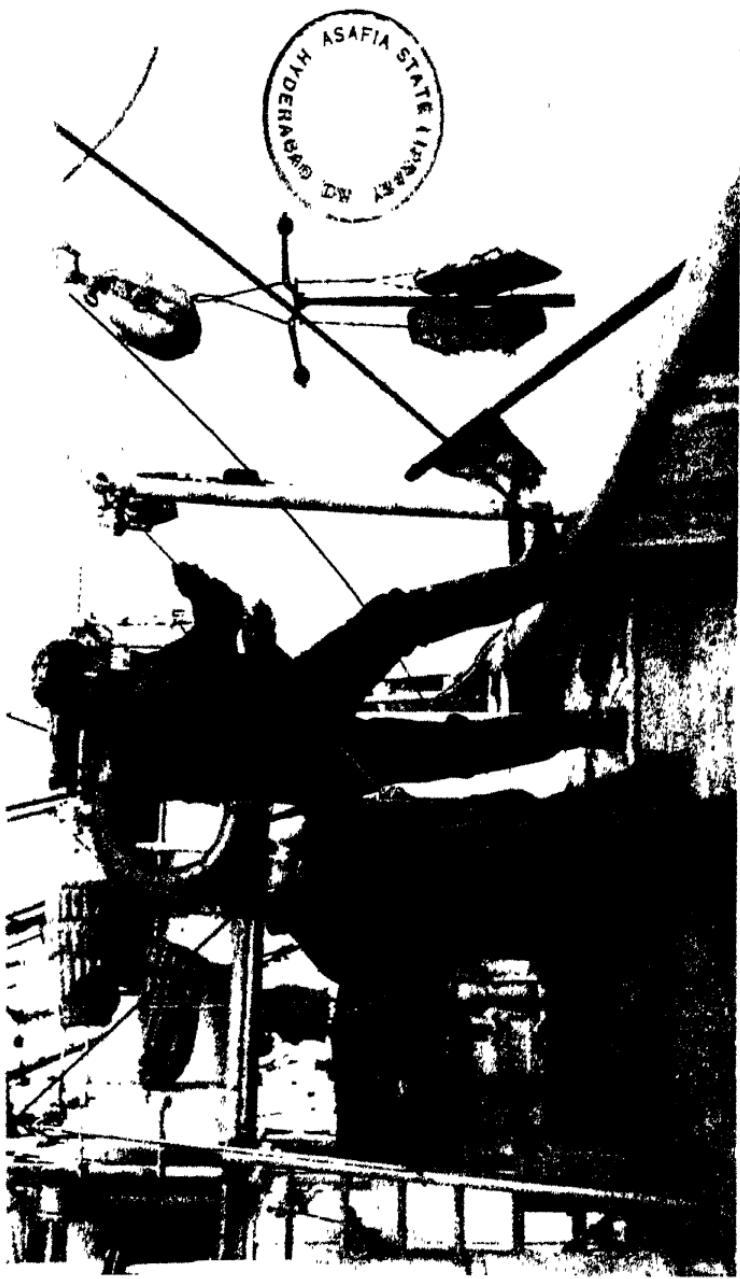
Another step forward was the invention of the bathy-meter, for measuring depth; this consists of a long glass tube closed at the upper end. It is empty when lowered, but because of the high pressure of the water the air in the

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tube becomes compressed, and the water mounts higher and higher in it as it is let further and further down. A trap prevents the water escaping when the lead is hauled in again, and from its height in the tube the pressure it has been exposed to can be estimated, and thereby the depth also.

Both the bathymeter and the piano-wire are used today, though they have certain disadvantages. These methods are slow, and in using the meter-wheel the line must be perpendicular if the measurement is to be accurate. At great depths it is sometimes hard to ascertain the moment when the lead touches the bottom. Especially in the Arctic seas, where time is usually precious, and where the largest unknown areas still exist, the latest marvel, the fathometer, has played a revolutionising part.

The fathometer works on the principle that sound-waves, in a downward course through the water, strike the bottom and are thrown back by this as an echo is thrown back from a rock-wall. Since the speed of sound-waves in water is known, it follows that from the length of time between the moment the sound is sent out and the moment the returning echo is heard, the depth of water beneath the keel can be calculated. The fathometer consists therefore of a transmitter, which sends the sound out into the water, a receiver which catches the echo, and finally an apparatus which registers the period between the two. A metal plate is attached to the bottom of the ship, which is set oscillating electrically, so that it gives out a short sharp whistle; also a microphone to catch the returning sound. In its simplest form the regis-

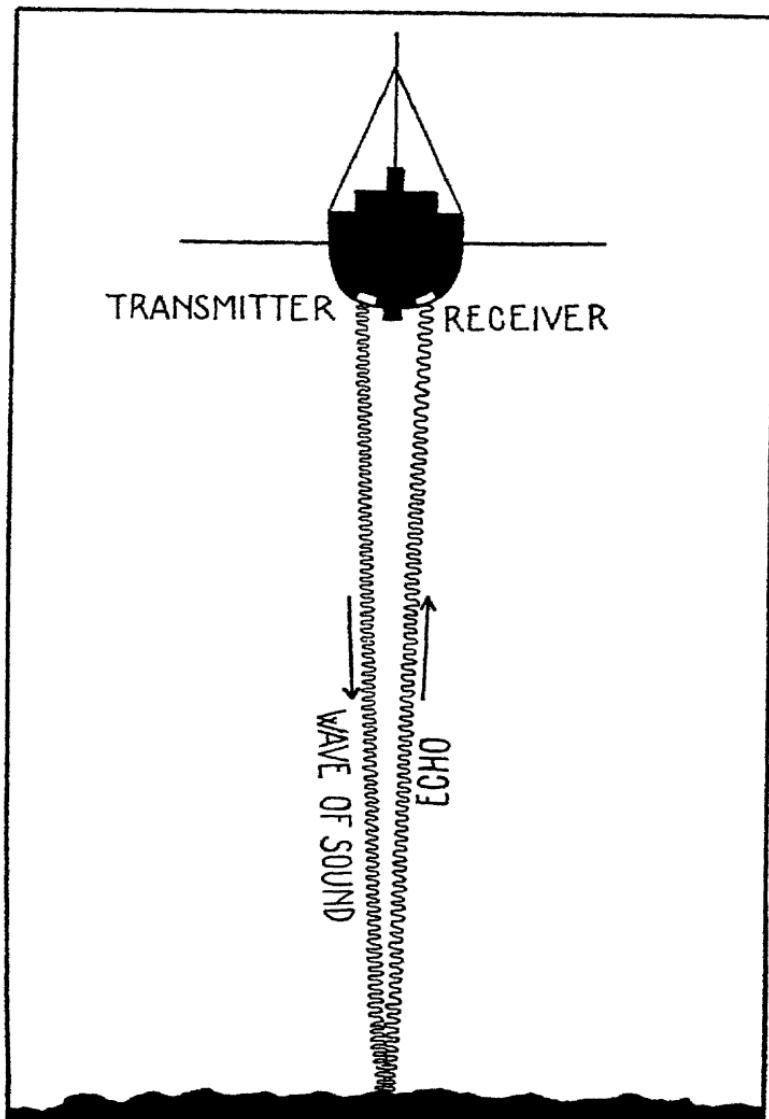


DEEP-SEA SOUNDING BEFORE THE INVENTION OF THE PATHOMETER

The lead is weighted with a couple of stones which are released when it strikes the bottom so as to avoid the necessity for dragging the heavy weight to the surface again



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THE PRINCIPLE OF FATHOMETRY

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tering apparatus consists of a big round disk which is turned at a constant speed. The edge of this disk is divided up into numbered sections representing fathoms. Every time the zero on the disk passes a certain point, contact is made and the noise is emitted. In front of the disk stands a man wearing earphones which are connected with the microphone on the ship's bottom. His eyes are fixed on the rotating disk, and note how far it has moved before he hears the echo. The disk is so adjusted that he can establish the depth immediately.

This system in its simplest form enormously facilitates work. No paying-out of miles of steel wire, no struggles to make the line fall perpendicularly; on the contrary, there is nothing to prevent the ship going unhindered on her way during the soundings. But present-day inventors have perfected the apparatus still further.

In the case of the model described, the accuracy depends on the man's skill and speed in reading the figures on the rotating disk. In the modern models, the man is replaced by an electric mechanism. By means of an involved and ingenious contrivance, a writing indicator has been achieved, which records the depth on a graduated paper scale. Not only that: when the apparatus is in motion, this paper revolves round a drum, as on an ordinary barograph, and while the ship sails along the surface, the registering machine traces a line corresponding to the bottom of the sea along the course steered. It is evident how much this must have added to the knowledge of the sea-bed in the Arctic. The accuracy of the charts thus made depends only on the closeness with

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which the parallel courses are steered, and simply by sailing back and forth over a sea men succeed in recording every tiny variation, every submarine rock or shoal. If in a fog one draws near land, the indicator starts to climb, and so gives warning.

The fathometer is not used only in ships engaged in research in Arctic seas. They cannot penetrate among the pack-ice and give us indications of the depth there; but once more the aeroplane comes to our aid. Both Amundsen and Wilkins had the fathometer fitted to their seaplanes for their flights over the Arctic Ocean; they alighted in the open water between the ice-floes and measured those mighty depths in a moment.

But almost incredible technical ingenuity in connection with this fathometer has been shown in the latest Russian invention.

In the summer of last year, the Russian flyers alighted on an ice-floe right up in the Polar Sea itself. They erected a strange and tremendously costly little house on the biggest floe they could find; and then they all flew away again. The building was an automatic station, which worked entirely by itself. By means of a system of machinery so complicated that it can hardly be grasped, measurements took place at regular intervals of barometric pressure, air-temperature, strength and direction of wind and the depth of the sea at the point where the drifting ice-floe happened at the moment to be. These soundings were taken of course by means of the fathometer. The results of all these observations were transferred — how, only the technicians under-

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stand — to a wireless transmitter. A clock set the whole mechanism going at certain intervals, while away on the nearest coast, hundreds of miles from the drifting station, watchful telegraphists sat and listened. And they were not content just to receive information about wind and weather and depth of water. By means of modern wireless detection they ascertained the direction of the station, which shifted from day to day. By comparing the observations of several land-stations, they were able to establish the position and the drift, and thereby the direction of the currents.

This last brings us to the next great field of marine research. The direction and peculiarities of the different ocean currents are the result of many different factors — the rotation of the earth, the prevailing winds, the shape of the land-masses and several other things. These currents play a most important part in Arctic regions. On the warm streams from the south, the lives of many animals and plants depend. The cold, northerly currents carry the drifting ice upon their shoulders; ice which is not only the chief obstacle to our approaching these shores, but which above all determines the climate of the region. The best example of the importance of these currents is obtained by comparing the coasts of Norway and East Greenland. It should be remembered that the southernmost point of Greenland lies on the same latitude as Oslo and Stockholm, so that large areas of the Greenland and Norwegian coasts are at equal distances from the North Pole. Norway has flourishing towns far up in the north, and big fisheries along the

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coast, and rye can be grown as far north as Tromsö, which is only just below the 70th latitude. All these facts are due to one thing, namely the great, warm ocean current, the Gulf Stream, which pours up from the coast of Central America and along the coasts of Northern Europe, where its influence is felt strongly as far as Spitzbergen. On the coasts of East Greenland, however, we find entirely Arctic conditions: a bare, almost uninhabited land, blocked by drifting pack-ice. Here everything is determined by the south-running current from the Polar Sea.

Investigation of these currents is the task of the hydrographer. In old days their course was learnt from the leeway made by ships, and by the drifting of objects from a distant coast. Above the shores of Norway we find coconuts and seeds which have been carried up on the Gulf Stream from the tropics ; while in Greenland the most important driftwood is tree-trunks which have drifted from the great Siberian forests down the rivers, across the Arctic Ocean and down along the east coast of Greenland. Men have attempted to do the same. After the finding off South-West Greenland of the wreckage of the *Janette*, the ship belonging to De Long the explorer, which in 1881 had been abandoned north of Siberia, Nansen carried out his exploit with the *Fram* as has been already related. In a later chapter, a corresponding feat by the Russians will be described, which we were able to follow in the wireless bulletins day by day during the past year.

But to-day the hydrographer avails himself of other

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methods. He subjects the chemical and physical nature of the waters to a searching examination. The temperature and saltiness of the water give a hint of its origin, and by determining its density, the scientist can embark on the difficult dynamic calculations which will give the direction and force of the current. It is therefore necessary for the hydrographer to obtain samples of water from different depths, and subject them to minute examination. For this he uses a water-bottle; this container is let down to the required depth, and a pierced lead, which is sent after it down the line, releases a locking device. The method of using it is as follows. A whole series of these containers is attached to a steel wire at given distances from one another. For instance, the first may be 100 feet beneath the surface, the second 150, the third 300, and so on. Under each water-bottle hangs a little lead which is sent on down the line when the container is released. When all the containers are at the desired depths, the first lead is sent down from the ship, which strikes the spring of the first water-bottle, and at the same moment the next lead falls. And so on right to the lowest container, which lies against the bottom. In the Arctic seas a depth of from 10,000 to 15,000 feet is often reached. When the water-bottles have been hauled up, samples are taken for the different analyses, while the vessel sails on to the next 'hydrographic station'. These stations are arranged in sections across the channel to be examined, and at right angles to the currents in the channel.

There is another way in which to study the ocean cur-

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rents, which is more easily understood but less accurate. One can deduce facts from the organisms which live in the water and follow them in their course, just as one can with the coconuts or the Siberian driftwood. For there is teeming life in the waters; tiny creatures, some of them crabs and snails, and others which belong rather to plant life, such as Diatoms and Peridinians. The common name for all these organisms which live in open water is plankton. As a result of the plentiful nourishment carried out to sea with the help of glaciers and mountain rivers, and of the vertical current which carries nutritive salt up from the ocean bed, the Arctic waters are richer in plankton than more southerly seas, and the microscopic creatures are often so thick in the water that the surface loses its usual blue colour and becomes green or brown. Even the early explorers were familiar with this phenomenon, and a hundred years ago ships' doctors and others who carried on the scientific work were instructed to study 'the matter colouring sea and ice in the Arctic regions'. Whalers knew too that this plankton has somehow or other an effect on the number of whales to be found; and the fishing did not begin until the experienced pilot had guided the ship to those regions where the water was brown or green. They came to know that the whale's most important food was the larger plankton organisms, which were strained through the network of baleen, or whalebone.

These little organisms are almost without the power of movement, and are therefore carried along automatically in the currents. In a strait where one current flows south

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along one side, and another towards the north, each of these currents will be characterised by its own kind of plankton, and simply by looking at a sample under the microscope it is possible to tell when one has passed from the one to the other. The writer has just completed the examination of some hundreds of plankton samples from the waters between Canada and Greenland. With the help of this plankton it has been possible to determine the limits of the different currents, and it is now known that the cold stream which flows along the East coast of Greenland does not after rounding Cape Farewell run north again, as was supposed, but swirls away from the coast towards Labrador. And the extent of the strong, southward-flowing current along the west coast of Baffin Bay and Davis Strait has been recorded.

Detailed charting of these ocean currents is not of scientific interest only. We are not solely concerned with the fact that different Arctic shores have different climates, which are determined by the prevailing currents. The course of these currents has also a purely practical interest. The variation in the numbers of fish on the rich Arctic Banks is connected with the variation in current at different seasons. And we need only remember the disaster of the *Titanic* to realise that the Arctic currents which carry ice-bergs southward with them are of grave importance to the shipping between Europe and North America. It is that southward current through Davis Strait which is particularly rich in ice-bergs, and not only have several expeditions been sent into that region, but the Americans have established a



AN ICE-PATROL AT WORK

When an iceberg coming from the north has reached the shipping route of the Newfoundland Banks, it is met by an ice-patrol ship which does not leave it until it has melted. The vessel constantly gives, by wireless, the position of the iceberg to all ships coming into that area; this is particularly important in fog. Meanwhile the patrol-ship tries to speed up the melting by blasting it with dynamite.



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permanent service, the 'U.S. Coast Guard', controlling a number of sea-going vessels, whose sole duty is to be on ice-patrol off Labrador, and by means of wireless give the liners timely warning of the most dangerous of the bergs.

With the plankton research we find ourselves in a transition stage between hydrography and biology. The investigation of animals and plants in the sea is also an important part of marine research.

Zoologists catch the larger plankton organisms in huge bags which are towed astern of the ship. A whole row of these is made fast to a steel hawser, the weight of which keeps the bottom one at a great depth as the ship moves along, so that each bag takes in its catch at its own level. For there is an enormous difference between the creatures at the various depths. When the bags are hauled in, the zoologists are ready with big tubs into which the masses of teeming life are emptied. Most of it consists of prawns and different kinds of crustaceans, but there are also strange pteropods and little squids swimming round in the living mass, young fish of wonderful colours, fish-eggs as clear as water, and much besides. These creatures are at once sorted and each kind is weighed by itself and preserved in a jar for the purpose. If there are many prawns, the cook gets a bucketful of them in the galley, and soon a feast is going on all over the deck.

Very different from this floating life are the creatures of the ocean-bed. This we explore with the help of the trawl, which is dragged along the bottom. Some of the

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most exciting moments in the history of an expedition are those when the trawl comes to the surface again, and the zoologists empty it out. Here are huge starfish and sea-pens (*pennatula*), corals and revolting-looking sea-slugs (or *trepang*), strange species of fish and big mussels. Down at great depths there exist many different kinds of creatures, and if the trawl is drawn up at night, they glow green and yellow. The fish have shining lamps on their noses, the crabs have a whole row of bright bulls'-eyes along their sides, and the 'sea-pens' shine like suns. And during the sorting of these, the luminosity spreads itself all over the deck. Nets and tubs give out a bright glow, and the hands and boots of the men engaged in the work are luminous too. If the examination takes place while the Northern Lights are flaming in the sky, the scene is breath-taking.

The living contents of the trawl are sorted into jars of formalin, to preserve them until they can be examined more minutely at home. But for detailed examination of the animal life of the sea-bed, the zoologist is not content with the trawl. He wants to know also in what quantities the creatures are to be found. For this purpose another apparatus is used: the 'grab'. This is made of wrought-iron, and resembles the clutching apparatus familiar to us from cranes at home. This is sent to the bottom open; then two huge iron jaws bite together, taking in a square yard of the sea bed, with all the life to be found upon it, or in it. When this mass comes up it looks simply like a mass of mud, but afterwards it is all filtered by a system of sieves, and the animals appear. This time the zoologists

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are more particular in the sorting, and let nothing go. Worms and sea-porcupines, sea-stars and mussels, all are collected and carefully weighed. In this way we obtain an understanding of the 'produce' of the sea bed. These creatures serve as fodder for other beasts, including the fish, and by learning the proportions we draw up part of the balance-sheet of the 'ocean budget'.

Apart from their scientific interest, these investigations help us to understand the size of the fish and their rate of spawning. The young of the fish appearing in the plankton sacks give us an indication of the manner of breeding and at what age the fish arrive at fishing-grounds. The grab helps us to discover how many fish can live there. And for the understanding of the biology of fish, the practical zoologist has even better methods. He lets down his hooks on the Banks, and hauls up great cod and halibut. He measures them, determines their sex and age, and lets them go again, but not before he has marked them with a little tag of ebonite, numbered, which he fastens with a silver thread to a fin, or a gill, and which is quite harmless to the fish. It corresponds to the ring-marking of the birds. A certain number of the fish may be hooked in perhaps some quite different part of the world, and thus the zoologist learns something of their journeyings, and in what seasons these are made. Cod marked high up on the west coast of Greenland are found in the Icelandic fjords, having covered vast distances in the meantime.

Nowadays the zoologists are not satisfied with merely marking the birds and the fish. Norwegian scientists

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have carried the idea still further, and for the first time this has been done in the case of young seals by fixing a small ebonite button in the skin of the flipper. Immediately after birth the young seal lies helplessly on the ice floe, and it is then that the marking takes place. For the rest of their lives the seals travel about wearing this identification mark, showing when and where they were born. It is hoped that by this means it will be possible to ascertain the wanderings of the seals, and to solve a number of the problems presented by these creatures; such as either to confirm or disprove the theory of the Greenlanders that the decreasing number of seals along the coast of Greenland is caused by the hunting of the young seals by Europeans in the Arctic Ocean.

Perhaps here more plainly than in any of the other scientific branches, one sees how such marine research will become important in many respects for the practical development of the Arctic. In the first place, as we have seen, the soundings and the charting of ocean currents alone are of essential importance to shipping. Then biological research registers the distribution of the sea-creatures, from the microscopic plankton organisms to fish, seals and whales. We have found many times that scientific expeditions have discovered new fishing-grounds which have been of great practical value. A classic example of this is Ad. Jensen's proof of the presence of cod off the West Greenland coast, which was followed up by the great fishery now being developed, in which many nations take part. This discovery was perhaps even more important for the Greenlanders, who thus obtained a

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new source of food at a time when the seals which were so important to them were diminishing in numbers. Codfishing is now one of the most important resources of the Greenlanders. But zoologists continue to busy themselves with scientific investigations among the fish of these regions. They still try to ascertain the age of those caught, so that it may always be known which year's are dying out, and also whether there is any influx from other places, or whether the fish show a tendency to leave the coasts. In this way one is in a position to regulate the fishing and be prepared if the fish should disappear, as has happened several times off the Greenland coast. The scientists are on the watch also for new conditions, and if new species appear that can be used, the fishermen are immediately informed.

For these reasons, co-operation between scientists and practical workers is also greatest in marine research, and the importance of the Arctic marine research expeditions is evident even to those who cannot immediately appreciate the value of scientific investigations whose practical results remain hidden in a distant, unpredictable future.

CHAPTER VII

THE PEOPLES OF THE ARCTIC

Modern expeditions to the Arctic stand in two kinds of relationship to the people who live there, and have two tasks. The first of these is purely scientific; we try to learn something of Eskimo living conditions, and to throw light on the questions of how these races have been able to adapt themselves to their Arctic surroundings. We observe the ways in which they are able to keep themselves alive, and in connection with this we examine the particular degree of spiritual culture which has developed, thus gaining some insight into their religion and their philosophy of life. Of greatest interest to us perhaps is their history; and we inquire how this adaptation to such extreme conditions has come about, and what was the place of origin of these races in ages past.

The second task of the modern expedition is practical, and is connected with the exploitation of the Arctic regions, which is the less immediate goal of exploration. This goal is not merely the acquisition of wealth for those nations holding sway over the Arctic regions. It is becoming more and more evident to all concerned that the development to be aimed at is one which will preserve the peculiar qualities of the Arctic peoples, while yet adapting them to the encroachment of modern civilisation; for it is stretching out its tentacles to these countries too. We are not trying to ward off a culture

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which is inevitable, but instead to render it advantageous to the primitive people by helping them over the difficult adjustment. Even when exploring uninhabited regions, men keep their eyes open to any possibilities there may be for the expansion of the activities of the Arctic people in these places too. More important still is it to discover new sources of supply for them, so that with the least possible friction they may be absorbed as a part of the great production-company of the machine age, which in our century has helped to smooth out characteristic differences between the nations. It may be said at once that this attitude is comparatively new. Like all other primitive races, the peoples of the Arctic have been subjected to the relentless exploitation of the white man, and their history is full of examples of oppression and merciless treatment, which have resulted in their almost complete extinction, or at any rate in living conditions of extreme wretchedness.

The relationship of the modern expedition to the polar peoples has therefore two sides, and we shall begin by examining the one which was mentioned first. We shall see how those scientists set to work, who have made a study of the life and history of these races.

By 'peoples of the Arctic' we may designate those who have developed a special culture along the coasts of the Arctic Ocean. Those, that is to say, who have made themselves masters of cold and darkness, and who depend primarily on the creatures in the ice-filled water-ways. We will pass by the Lapps and certain Siberian races, which do indeed live in the far north, but whose civilisa-

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tion is not specifically Arctic, since it is bound up with that of the mainland south of those coasts, and thus is not so essentially different from other mainland races. In the following pages we shall only be paying attention to the Eskimos, who hardly ever live south of the forest-line, and who have managed to make a life for themselves so identified with the harshest natural conditions that the study of their civilisation fills one over and over again with admiration and respect, and makes one realise that its development must have taken many generations.

In our own day the Eskimos are almost exclusively connected with the north American continent, since only a small tribe is to be found on the western side of the Bering Strait. Thus they live mostly along the coasts and sounds of the Arctic Ocean from the Bering Strait to Greenland, and also along the shores of Alaska, and of Baffin Bay as far as Labrador. They are divided into different tribes, each with its own peculiar characteristics, and yet at the same time having many features in common; and it is particularly interesting to find that the language varies so little over all that great region. An Eskimo from the north-east corner of Siberia can understand a Greenlander, despite difference of dialect. How and where this common culture originated, and how the migrations along the coasts took place, are important questions to the scientists.

The Eskimos have no written records of earlier times, and their verbal historical traditions are hidden in the haze of their mythology. We must therefore go to work another way. Experts from several different branches of

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research here work together. The philologist helps the anthropologist; the ethnographer is supported by the archæologist. Each one of them does what he can towards determining the root from which all these tribes sprang, and the part of the world from which they made their way to the Arctic Ocean.

The philologist compares the different Eskimo dialects. Eskimo speech is polysynthetic, which is to say that individual words consist of roots to which are added suffixes, whose peculiarity is that they cannot stand alone, but when added to the root indicate in what sense this is to be taken. Thus the two hundred or so suffixes in the Eskimo speech can be added to all the different root-words; and an amusing fact is that to one of these a whole string of suffixes may be attached. Take for example the word *igdlorssuatsiarliorfigssaliarqugamiuk*. Here *igdlor* alone is the chief word, and the rest are additions indicating the sense in which the word *igdlor* or house, is to be understood. If we divide the whole word into its component parts it stands simply as follows:

{*igdlor ssua tsiar lior fi gssa liar qu gamiuk*
 {house big rather build place coming go ask when he him.}}

Or in other words, 'when he asked him to go to the place where the rather big house was to be built'.

By this alone it will be realised that the Eskimo language is not an easy one to learn, and that Eskimo dialects are a life-study. The demonstration of how by successive mutation one dialect developed from another is the part of research of most importance for the understanding of the migrations, and of the Eskimos'

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history and the languages which have the fewest of these mutations are reckoned then as the most primitive. Next the object is to find out which words are common to all the tribes, and which have been borrowed from neighbours. The Danish Eskimo expert H. Rink was in this way the first to demonstrate that nearly all the words relating to the sea, the names of the various kinds of fishing-gear, and the expressions for ebb and floodtide and salt water were common to certain tribes. From this he concluded firstly that the Eskimos had still formed one main group at the time when they reached the sea, and secondly that the special Eskimo culture did not originate before this time. Nevertheless, the circumstances are so complicated that philologists have not yet reached any fixed conclusion as to the Eskimos' place of origin.

The anthropologist examines the physical type and compares it with that of other races. He measures the size of the skull and determines its shape, he observes the setting of the eyes, and the colour of the skin and hair. In general we are inclined to believe that Eskimos are Mongolians, and related to the inhabitants of northern and central Siberia. But the position is considerably more complicated than this, and the theory of kinship with the North American Indians cannot be altogether rejected. There are some explorers who hold the view that Eskimos are native to America, and have come up from the south through the central part of the continent.

Both anthropological and philological research therefore involve great difficulty, and up to the present the findings are vague. We must now see whether the other

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branches can help us; that is to say we must turn away from the people themselves and regard the outward signs of their civilisation — their tools and dress, the types of their buildings and their skin boats.

The ethnographer studies the surviving tribes. Every little group is treated separately. Their household utensils and fishing gear are collected, and compared with those of other parts.

If we are content to generalise, we can say that the ethnographer differentiates between three different cultural types. In the most northern settlements of Greenland live the most northerly people of the world, belonging to the High Arctic Cultural Type. They live in a land where wintry conditions prevail almost all the year round, and the ice remains for something like ten months. For this reason their methods of hunting are adapted to icy conditions. The chief hunting-season is in the spring, after the enforced winter rest of the polar regions, and the Eskimos move out on to the ice to hunt seals, narwhals and walruses. Their most important means of transport is the dog-sledge. On the other hand, the Eskimos of the high Arctic who were most typical had neither kayak nor umiak (or ‘woman’s boat’), and in the summer when for a short time it was impossible to use a sledge, they kept to the hills where the birds were, and where the women made warm under-coats from birds’ skins. After renewed association with other branches, these Eskimos have now adopted the kayak and, since white civilisation reached them, they have come much nearer to their southern kinsfolk in their



A LITTLE GREENLAND GIRL. FROM UPERNAVIK

'There is no particularly Mongolian stamp to her features; they are more Indian. There is no doubt Danish blood in her veins.'

A HUNTER FROM WEST GREENLAND

'The features in this case are more suggestive of Mongolian connections'



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whole manner of living. Yet I myself remember that in 1928, when I went up to Thule from West Greenland, the difference was evident. The men indeed had good rifles, but the clothes were different, the hunters wearing heavy white polar-bear trousers, and the women beautiful little ones of blue and white fox.

True Arctic Culture is to be found in different degrees extending over by far the greater part of the Eskimo region. Its characteristic is that hunting goes on all the year round, in winter with a dog-sledge, and in summer with the kayak and umiak. The winter is not so dark as greatly to hinder hunting, so that unlike the polar Eskimos, they do not need to lay in great stores of meat in the course of the spring hunting. This central civilisation extends from Greenland along the whole of the North American coast, where in the summer whale-fishing from umiaks plays, or played, an important part.

The Sub-Arctic Culture differs from the others in having made a speciality of hunting from boats. This is not confined to the big ocean mammals, but many different kinds of fish are sought. This type of civilisation is common in places where ice seldom or never covers the sea and fjords during winter: that is to say in South Greenland and on the Pacific, including the Aleutian Islands, and is further characterised by the fact that the dog-sledge is not used.

All three have this in common, however: their existence depends on sea-creatures. An important household article therefore is the blubber lamp: a hollow stone, in which they burn the blubber of these animals, and are thus enabled

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to cook food and keep warm in a land where there is no wood for fuel. It can be assumed that the two subsidiary cultural types derive from the central one, as the High-Arctic people have only forgotten or abandoned the kayak, and the Sub-Arctic, under an impulse from the south, have abandoned the dog-sledge.

It is interesting, however, to note that there exists a tribe of Eskimos who are ignorant of the use of the blubber-lamp, but can manage with the poor fuel of heather and moss. These are the Reindeer Eskimos, who live about the west coast of Hudson Bay. They were the subject of special study by Birket-Smith, on the great Fifth Thule expedition, in the course of which almost all the Eskimo tribes in America were visited by the leading Eskimo-ethnographer Knud Rasmussen and his colleagues. The civilisation of the Reindeer Eskimos, as the name suggests, is bound up with the reindeer, and only occasionally do they move out to the coast to hunt sea creatures.

From the fact that the Reindeer Eskimos lack the blubber-lamp, so characteristic and essential a feature of Eskimo civilisation, Birket-Smith thinks it reasonable to conclude that these people may be a remnant of the most primitive of their kind. And his detailed investigations lead him to the supposition already made by the Dane Steensby in the previous century, that originally the Eskimos were an American inland people who were forced northwards by the Indians to the coast, where their culture originated and spread along the shores.

But what does the archæologist say to this theory? He

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studies the remains of earlier civilisations. He visits the regions formerly inhabited by Eskimos, and digs among the half-buried ruins of their houses which he finds along the Arctic coasts.

These excavations can be very laborious, as the earth immediately beneath the surface of the soil is frozen. Attempts have been made to melt the ground with blow-lamps or hot water, but this is much too troublesome. Instead the archæologist is careful to have several excavations going at the same time, so that he can leave the thawing-out to the sun. Thus each day he advances a little further in his various diggings. As a recompense, he finds that this frozen soil has preserved the things he is seeking. Implements hundreds of years old are as good as new, and objects of fur and skin can be found which would have disappeared long ago in land farther south.

The mere shape of the house gives the archæologist some indication of what civilisation it is with which he is concerned. The houses may be round or square, they may be joined together or separate; but the archæologist digs his way carefully down along the walls of huge stones, and removes with quite a small spade the earth which has collected in the interior of the building. And it is here that he finds the tools and implements which were left there when the place was abandoned, either because they were worn out or because they had been forgotten in the bustle of leaving. Stumps of harpoons, broken stone cooking-pots, carved toys, and jewellery of walrus teeth come to light, and women's small possessions, such as needle-cases, dippers and wooden dishes.

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From the men's weapons, and from the animals' bones found there, we learn what was the chief food of these people. Things found both indoors and outside tell us whether or not they had knowledge of the dog-sledge and kayak; and by collating all these small pieces of evidence, we gain an impression of the type of culture we are faced with. Systematic excavation over the whole Eskimo district gives us information about the migrations of earlier days, and about the civilisations which are off-shoots of one another.

Let us take, for example, the investigations which have been carried out in recent years in Greenland, mainly by the Dane Therkel Matthiassen. Archaeologists have discovered that the Eskimos came in far to the north at Smith Sound, and thence came southward along the west coast. This migration took place from the tenth to the twelfth century. The primitive civilisation we meet with here was called the 'Thule Culture', and Matthias-sen found corresponding traces of it in Canada. On the way south a new type of culture developed, partly from the altered conditions and partly from the influence of the old Norsemen who were living here when the Eskimos arrived. This newer civilisation was called the 'Inugsuk Culture', and traces of it have been found in excavations in the neighbourhood of Angmagssalik on the south-east coast, so that the Eskimos must have rounded the southern point of Greenland. How far north did they get on this journey?

The scientists of the Three-Year Expedition, particularly the Danish archaeologist Helge Larsen, have made



RUIN OF AN ESKIMO HOUSE

It is seen from the back looking towards the entrance. The roof has collapsed and disappeared, only the walls remain. This was found in Kangerdlugssuk, in the now uninhabited part of East Greenland.

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thrilling observations here. It appears that we can find traces of the Inugsuk Culture up as far as North-East Greenland, but it is mixed with that of an older era, corresponding to the Thule Culture. This mixed culture persisted in East Greenland for three or four hundred years, until the entire population died out, for reasons unknown, in the middle of last century.

We saw that types of culture corresponding to that of Thule were found in Canada, and it is from here therefore that the Greenlanders must have come. The archæologist could thus join with the ethnographer in believing that the Eskimos are an American race which reached the coast somewhere in Canada. Above all, the fact that we lacked all information about early Eskimo habitations in North Siberia, and also that the Eskimos of the Bering Coast had a derived culture, which showed a markedly Indian influence, also went to support the theory of Steensby and Birket-Smith.

It is interesting to note that quite recently, in the summer of 1937, we received new information which seems to point in quite another direction. An American archæologist, H. B. Collins, has shown the existence of a hitherto unknown culture on St. Lawrence Island which he calls the Old Bering Strait Culture, and which is mainly characterised by rich ornamentation; and Collins is of the opinion that in this we have an ancient Eskimo cultural element — perhaps the oldest in America. In other words, one may assume that the Eskimos came to this part of the world over the Bering Strait from Siberia. Recently the astonishing information came from the

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Russian archæologist Chernetsov that he had found ruins of houses right over on the Jalmal peninsula, north of the Urals, which he considered to be Eskimo; and this taken together with the other findings assumes some importance.

It seems therefore as if the mystery surrounding the origin of the migrations of the Eskimos, which during the last half-century has occupied philologists, archæologists, anthropologists and ethnographers, will now be solved by the archæologists, and we await with eagerness the outcome of the Russian investigations along the northern coasts of Siberia. And might not the day come when we may start searching for Eskimo relics in the northernmost parts of Scandinavia? At the risk of being ridiculed by archæologists, one might feel inclined to describe as Eskimo the mysterious Komsa culture in the most northern part of Norway, which has so greatly occupied the minds of Scandinavian archæologists of recent times. By this we close the ring round the whole of the Polar Basin, and at the same time lift a corner of the veil which hides from our eyes the earliest colonisation, when the ice of the Ice-Age first receded.

With a leap of a couple of thousand years or so, we return to the Eskimo of to-day, and touch upon the second task which lies before the modern expedition.

At the present time there are hardly as many as 40,000 Eskimos in all the gigantic expanse of Arctic America and Greenland. Until the middle of last century they were able in most places to live comparatively undisturbed by the white man, as only Dutch and Scottish whalers had

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any intercourse with them. But in time enterprising merchants began to realise that Eskimos had valuable goods to sell. They hunted the blue and white fox, ermine, and polar bears: beasts for whose skins there was a demand as luxuries further south, but which for Eskimos were necessary, as protection from the cold. These skins were bought from them. The Eskimos with their undeveloped mentality have little thought for the morrow, and they bartered them away for relatively worthless European goods, so that when winter came they were without the necessary clothes. It was worst for the Eskimos in Alaska. Russian merchants overran the country, cheated the naïve inhabitants, treated them brutally, and introduced spirits and all imaginable diseases. The Eskimos were accustomed to pure, germ-free air, and were therefore highly susceptible to disease, which spread very rapidly and laid waste many dwellings.

It was little better in Canada. Here the great trading firm, the Hudson's Bay Company, has almost a monopoly in trading with the Eskimos, and they deal especially in fox-skins. They pay well for them, but as the Danish Eskimo expert A. E. Porsild points out, the Eskimos, who do not look far ahead, confine themselves entirely to catching foxes. They have no time to go after seals, fish or reindeer, but buy through the trading company the white man's substitutes. The change from meat to bad soggy wheaten bread, baked over a primus stove, and from seal and walrus-blubber and reindeer fat to pigs' fat and vitaminless margarine or bad butter, has not been an advantageous one to the Eskimo. They have

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bartered their health and powers of resistance to infectious diseases, especially influenza and chills, which follow in the steps of the white man. Certainly the Eskimos received sewing-machines and gramophones, and typewriters are not unknown in the Eskimo huts at the delta of the Mackenzie River, but the whole tribe was enfeebled, and lived actually in great misery.

It began to be realised that this could not go on. There was also a business side to it; it did not pay to let these races, who obtained the precious skins, die out. As early as the eighties, therefore, after Alaska had been bought from Russia, a series of expeditions was sent out from the United States to find the best means of preserving the Eskimo races. The result of these investigations was that in the years from 1891 to 1902, 1,280 reindeer were introduced into Alaska from Siberia. The Eskimos learnt to care for these animals, which have so increased that there are now 750,000 tame reindeer there, besides the 200,000 which in the course of years have provided the Eskimos with fresh meat, and skins for clothes and tents. This successful experiment has really saved their lives. In 1926 the Canadian Government began to take an interest in the matter, and two Danish Arctic explorers were invited over to convey a huge herd of reindeer from Alaska to the Eskimo district at the mouth of the Mackenzie River. The account of this transportation is one of tremendous adventure. It took several years to drive the reindeer those 1,250 miles. Three thousand reindeer left Alaska, 2,370 reindeer arrived at the Mackenzie River, but of those only 600

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were of the original herd: the rest had been born on the way.

Modern exploration has thus taught Eskimos how to breed reindeer, and thereby attempted to remedy some of the old damage. But the scientists seek to help the Eskimos in another way also. It has already been told how after Jensen's investigations it became possible to introduce cod-fishing into West Greenland. Experts have discovered where the cod is, and keep an eye on their numbers, while the administration sees to procuring fishing-gear and boats for the Greenlanders, and sends up fishermen from Europe to teach them the art. Archæologists have shown that the old Norsemen bred cattle when they lived in South Greenland in the fourteenth century, and this has led to cattle-breeding among the present-day Greenlanders there, and sheep-rearing in particular has become a very important activity.

Geologists have found big marble deposits, and many Greenlanders now earn their living by working in the big quarries. One of the chief tasks of the Three-Year Expedition was to find out whether Eskimos could live in North-East Greenland. The zoologists examined the fish and game available, and the archæologists found out what the former inhabitants had lived on, so that we now know whether with an increasing population it is possible to bring Greenlanders over to this region too.

Special groups are sent out to observe the health of the Eskimos and their living conditions. A year or two ago a Norwegian doctor lived among the Angmagssalik Eskimos to find out whether the natives' food was suffi-

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cient and whether the vitamin-content in the nourishment they now get was large enough to ensure them against weakness and illness. Many other physiological investigations also have been carried out within the last few years.

The Eskimos are the natural inhabitants of the Arctic. The aim of modern exploration when it tries to establish the lines along which future development of the region will take place, is to do it in such a way that the bargain profits not only the nations in the south, but above all those people who for thousands of years have been the true owners of the land.

CHAPTER VIII

POLAR VOYAGES OF THE MOST RECENT TIMES

With the development of flying during and after the world war, aircraft came to be regarded as an increasingly safe means of transport. Experiences gained in the war were turned to profit in peace-time, and development went on rapidly. New and better patterns of machine were built, materials were subjected to severe tests and record after record was broken. The beginning of the twenties was the time of the altitude and long-distance flights.

Naturally men were eager to try out the new means of transport in Arctic lands. Here were areas which were enormously difficult to reach by ship or sledge, and flying was the natural alternative. And at the same time there was practical work to be done. Here were still parts of the globe which were relatively unknown, and which offered the possibility of new discovery. This alone was incentive enough; but there was more to it than that. Wireless had also advanced, and this meant not only greater safety, but — which proved to be almost as important — it was possible to maintain continual contact with civilisation. Interest in these enterprises could be kept alive, so that they ran no risk of being forgotten as had sometimes happened with early expeditions of which nothing had been heard for a long time. Wireless

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even made it possible to make good journalistic copy of these flights, and the great news-agencies competed for the rights of the hastily telegraphed reports. In this we can see a contributory motive to some of the flying expeditions at the end of the twenties. There was indeed great personal courage shown, and experience in the handling of aircraft in the Arctic was dearly bought; but for the rest one may justly say that some of these expeditions brought in very small results in proportion to the outlay.

The idea of reaching the Arctic lands by air had occurred to far-sighted men long before flying technique had become perfect enough to make such a project practical. Andrée's balloon-flight in 1897 from Spitzbergen was as bold as it was brilliant. A journalist, Walter Wellman, tried to improve on it with the help of a sort of dirigible airship with which he embarked on flights from Spitzbergen in 1907 and 1909. He was lucky enough to survive these, and therefore his name will not be well known to posterity, but the amount gained by them did not encourage anyone else to try at that time.

The first real aeroplane flights in the Arctic were undertaken by a Russian, Lieutenant Nagursky, who had his base at Novaya Zemlya. These also were carried out successfully, but man's daring was still ahead of his technical achievement.

The flight which drew most general attention to the possibility of exploring from the air was the Amundsen-Ellsworth in 1925, of which the goal was the North



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AMUNDSEN'S TWO FLYING-BOATS N-24 AND N-25 ABOUT TO START FROM KINGSBAY IN
MAY 1925



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Pole.¹ Years before, Amundsen had made several unsuccessful attempts in Alaska, in which two machines were smashed to bits in the first trial flights. Now, in 1925, the American millionaire Ellsworth, among others, provided him with two Dornier-Wall flying boats with which, on May 21st, 1925, he took off northwards from Kingsbay, Spitzbergen. By the time Lat. $87^{\circ} 43' N.$ was reached, half the fuel had already been consumed, and the machines were brought down on to a patch of open water. Amundsen decided to abandon one of them, and to get the other one to rise, a runway had to be made, with infinite labour, on the ice. After a nerve-racking stay of no less than three weeks, during which time desperate efforts to take off were made, and lives risked at every attempt, the men were at last successful in getting the machine off the ground, and they returned to Spitzbergen on June 15th. An important thing done on this journey was the sounding, by fathometer, of the water where they had alighted, which showed that the depth at this point was not less than 2,000 fathoms deep. This fact went to support Fridtjof Nansen's theory of a deep polar basin.

The American explorer Richard E. Byrd, who afterwards became famous for his Antarctic flights, also undertook flights in the Arctic in 1925. He was attached to an American expedition, and made some masterly excursions into the regions round Smith Sound between Greenland and Ellesmere Land, in a little 'Loening-

¹ This and the following flights are marked on the map at the end of the book.

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'Amphibie' machine; thus he was the first to cruise over the inland ice of Greenland.

Byrd was also the first to reach the North Pole by air. He and his pilot Floyd Bennett started from Spitzbergen in a three-engined Fokker on May 9th, 1926, and only eight hours later were hovering over the North Pole, whence they skilfully navigated the machine back to Kingsbay. This record flight, which demonstrated to a high degree the personal skill of the two men, established the fact that there was no land between Spitzbergen and the Pole. This exploit took place two days after the dirigible airship *Norge*, piloted by Umberto Nobile, had arrived at Spitzbergen from Rome; possibly it was speeded up in order to forestall the *Norge*.

The *Norge* expedition was financed by Ellsworth and some newspaper syndicates, and started from Kingsbay with Amundsen and Ellsworth on board on May 11th, 1926. In four and a half hours the North Pole was reached, where the Norwegian, American and Italian flags were dropped, and from here the journey was continued over entirely unknown territory in the direction of Point Barrow, the most northerly promontory of Alaska. Though at the beginning weather conditions had been excellent, the airship encountered much fog and wind when approaching America. Certain stretches were crossed, therefore, without becoming visible, but on the whole the flight proved fairly conclusively that there was no land in this part of the Arctic Ocean either. On account of bad weather, the *Norge* landed at a little group of Eskimo dwellings called Teller. Since the wireless

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transmitter had gone out of order, some days passed during which the outer world was uncertain of the airship's fate. A sequel to the *Norge* expedition was a conflict between Amundsen and Nobile, which ultimately led to Amundsen's tragic end, and was a contributory cause of the attacks on Nobile after the *Italia* catastrophe. This conflict is without interest to the polar explorer, and need therefore not be discussed here, though it may throw a certain amount of light on the mentality prevailing towards the end of the twenties, as a result of record-hunting and the craving for sensation shown by the Press. This in its turn was brought about by rapid development in the fields of flying and wireless.

While hitherto all Arctic flights had started from the European side, the British explorer, Sir Hubert Wilkins, started his flights from Alaska in 1926. In that year and the year following he carried out several flights with Point Barrow as his base; most of them were short ones, with the main object of testing the efficiency and reliability of his machines. One of these deserves a fuller description, as in the course of it Wilkins landed on the ice north-west of Point Barrow, at about 78° N. His machine was fitted with a fathometer, which here registered the great depth of 2,800 fathoms. On the way home on March 29th, 1927, a powerful storm forced him and his companion Eilson to alight on an ice-floe about eighty miles off the coast of Alaska. For several days they drifted eastwards with the ice until at last on April 18th, after an eighty-mile walk, they regained land, having left their machine to its fate.

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Not until 1928 did Wilkins feel prepared to attempt a long flight. As the region between the North Pole and Point Barrow had already been traversed by the *Norge* he had no interest in reaching the Pole, but decided instead to fly over all the unknown tracts between the North Pole and the North American coast. On April 15th, 1928, he started from Point Barrow. From here he flew over ice-covered waters and found no land on his way to Grant Land, the most northerly in the Canadian archipelago. Having made his landfall here, he set his course towards Greenland, and landed, after twenty hours' flying, in Spitzbergen. The last half of the journey also was made over monotonous ice-fields without any land at all.

Wilkins's magnificent flight has been regarded up to recent times as the most admirably carried-out Arctic journey ever made by air. He followed a fixed and detailed plan, and displayed outstanding skill in his accurate navigation over an area where the taking of bearings is of extraordinary difficulty. He showed no interest in reaching the North Pole, which might have brought him acclaim from the Press, but set his course over regions the knowledge of which was of real geographical interest. He flew over a longer stretch than any other explorer had covered before him, hereby proving the value of those years of testing and experiment.

The *Italia* expedition also took place in 1928: the journey which more than any other was to cast the search-light of publicity over the Arctic regions. In the army of relief-expeditions of every kind which were sent

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out, and in the battle which raged openly about Nobile's name, interest in the expedition and its results were altogether submerged.

Taught by the experiences of the *Norge* flight, Nobile had another airship built in the spring of 1928, which arrived on May 6th at Kingsbay after an eventful journey. Nobile was greatly hindered by bad weather, which once compelled the airship to turn back, and continually menaced the fragile craft in its roofless hangar. Nevertheless a long flight was embarked upon over unknown territory to the west. The *Italia* flew round the northern coast of Spitzbergen, and along the northern coast of North East Land; then on along the north side of Franz Joseph's Land, as far as Long. 79° E., in the direction of the once very imperfectly known Severnaya Zemlya. After that the course was set south-west towards the northernmost point of Novaya Zemlya, along the north-west coast of which the airship flew for some way before returning to Spitzbergen. In all, this non-stop flight lasted sixty-nine hours — a unique feat which is very greatly to the honour of the leader and the crew. Through this expedition still more had been added to the knowledge of part of the Arctic. Something like 18,000 square miles of unexplored country had been passed over.

On May 23rd, Nobile started on the disastrous journey to the North Pole. The course was set in an arc towards Greenland, so as to cover territory where others had not been. After eight hours the North Pole was reached, and the flight back to Spitzbergen began. Two hundred and fifty miles north-west of Kingsbay harbour

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the disaster occurred. The airship dived on to the ice under power, and the shock tore off the pilot's gondola and the rearmost of the engine gondolas, while the rest of the airship, considerably lightened by this, rose once more and disappeared with six men on board. To this day nothing is known of the fate of the 'balloon-party'. Ten men landed violently on the ice with the two gondolas. One was killed on the spot, while Nobile and his second-in-command were severely injured. The others, among whom was the Swedish meteorologist, Malmgren, were only slightly hurt.

The weeks which followed were some of the most chaotic ever known in the history of Arctic exploration. Rescue expeditions poured in from all sides, and the regions of ice resounded with the roar of searching aeroplanes. Italian, Russian, French, Swedish and Norwegian aviators braved great dangers to find the castaways at the 'Red Tent', and vessels from everywhere steered their course towards this point.

To go into the details of the work of these expeditions would take us too far, and the only interest they can really have in an account of Arctic exploration is that they show how rapidly help may be summoned when one has wireless and aviators at one's disposal. Moreover, they have furnished us with the opportunity of seeing what can happen when such rescue-work is carried out more by the zeal and self-sacrifice of single groups than by co-operation and common sense. It may fall to the lot of future historians to unravel all the threads, and apportion the responsibility for any mistakes which were made; at



NOBILE'S 'RED TENT'

It was given this name because on the very first day Nobile painted red stripes on it so that it might be seen more easily from the air. In point of fact the paint rapidly disappeared and thereafter the tent was 'red' only in press reports



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present the incident is too recent for us to regard it objectively.

Put briefly, the events were as follows. With the gondolas was saved a certain amount of provisions and equipment; and, what was very important, a complete wireless transmitter escaped destruction. This was functioning the very day of the crash. Every hour S O S signals rang out into space—unheard. With bitterness Nobile learned through the receiving-set that the crew of the rescue ship *Cita di Milano* assumed them to be dead and wasted time with endless press-telegrams and private messages. Not till June 3rd were the cries for help heard by a Russian amateur in a provincial town near Archangel. Thanks to him, wireless communication was set up. But before this, Malmgren, after consulting Nobile, had decided that it was hopeless to rely on radio messages, and with two Italians had left the camp to try to get to Spitzbergen for help. Only the two Italians survived this heroic attempt to save them all.

At last the 'Red Tent' was found by the flyers, who had approached it several times without discerning it. But thanks to the radio communication now set up they arrived there and could throw down provisions to the castaways. On June 24th the Swedish lieutenant Lundborg landed at the camp and brought Nobile back with him to the base camp of the Swedish relief expedition. The fact that Nobile was the first to be taken off gave rise to great criticism. Actually, Lundborg had orders from Captain Tornberg, the Swedish leader, to take Nobile

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first, as he would be most competent to direct the rescue and also the search for the missing 'balloon-party'.

Nobile's arrival at the *Citta di Milano* was of little importance in organising the rescue of the others, since the captain of the ship, as a result of public opinion, did not pay much attention to Nobile's advice. In the course of the subsequent attempts at rescue, Lundborg's machine crashed when landing on the ice-floe, and he was not taken off by his companions until after an enforced stay of some time with the tent party. On July 12th the remaining five men were relieved by the Russian ice-breaker *Krassin* which had just taken on board the two survivors of the Malmgren party. These had been discovered from one of the planes in a miserable condition on an ice-floe.

Thus ended the last great polar catastrophe, which cost eight men their lives, and wrecked the career of their leader.

Nevertheless, the use of airships in the Arctic had not been abandoned. A group of scientists drawn from all countries agreed as early as 1925 to form an international organisation, the 'Aeroarctic', the object of which was the scientific survey of the Arctic from the air. In 1931 they succeeded in realising a carefully thought-out plan. What was perhaps the best airship in the world was at their disposal, and the pilot was Hugo Eckener himself, at the head of a skilled and thoroughly trained crew of thirty men. No fewer than fifteen scientists took part as representatives of different countries. From Germany the course was set first to Leningrad, where a land-

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ing-mast had been erected. Then for nearly four days and nights the airship flew over the polar regions, first via Archangel to Franz Joseph Land, where it made a beautiful landing on the water. Here mail was exchanged with a Russian ice-breaker. Next the journey was continued eastward to the unknown Severnaya Zemlya, which was now photographed with Dr. Aschenbrenner's apparatus (see page 75). Via the interior of the Taimyr peninsula and the whole length of Novaya Zemlya the Zeppelin returned to Leningrad, completing the finest airship flight made to date in the Arctic. The scientific achievements were not only the mapping of many hitherto unknown areas, but the recording throughout the whole flight of meteorological and magnetic observations.

Unfortunately, since this magnificent flight, 'Aeroarctic' has declined, mainly on account of the disturbed political condition of Europe, especially the coolness between Russia and Germany, the two countries who had been most active in this field, and who had had the greatest economic resources.

The renewal of Arctic flying came from quite another quarter than that of the scientists. The desire was felt to open a route between Europe and North America, and the interest of pilots and the big transport companies was concentrated on the far north. Throughout every summer, up to the present time, numerous test-flights have been made between the two hemispheres.

At first a southerly route from Europe via the Faroes, Iceland and Greenland was considered. Flights were

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made in both directions with varying success. In connection with Pan-American Airways a series of wintering expeditions was organised, with the sole purpose of investigating meteorological conditions, and the facilities for landing. The American Professor Hobbs stayed for years in West Greenland at the edge of the inland ice, while in East Greenland an expedition went to work under the leadership of Gino Watkins, who was drowned there in a kayak. The interest of the press reached its height when Lindbergh himself made the flight from America to Europe, cruising over the inland ice at Lat. 70° N., and with his wife visited Lauge Koch's stations in East Greenland.

But in the most recent years, during which aeroplanes have become better adapted to long-distance flights, even bolder attempts have been made to establish this trans-continental route. The Russians had the right idea when they confirmed the fact that the shortest way from Northern Europe to the heart of America leads over the North Pole. The Russians take a long view of it. They describe their great circle on the globe itself, and demonstrate that while the shortest route from Moscow to Chicago passes across North Greenland, the shortest way from London to Tokyo takes one over the most northerly part of Siberia. The Russian pioneers who are engaged in the preliminary work in these regions, picture to themselves great airports being erected in the depths of the Siberian tundra. They believe that it will not be long before the great 'Shanghai-New York' machine glides down, and the conductor shouts 'Change here for

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London and Moscow!' or 'Next stop on the North Pole route, Frisco!'

In the meantime the Russians have accomplished the great preliminary task of establishing a huge network of



THE GREAT CIRCLES: THE SHORTEST ROUTES BETWEEN THE CHIEF CITIES OF EUROPE, AMERICA AND ASIA

meteorological stations on all Arctic islands north of Siberia. In the summer of 1937 they were ready to begin the trial flights. On June 18th Tchukaloff embarked with

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two others on a long-distance flight, in a new machine ANT-25: a twelve-cylinder monoplane of 950 h.p., with 1,750 gallons of petrol on board. Fifteen hours later they were over the North Pole, and after a total flight of fifty hours twenty-two minutes, they landed at Vancouver, in the extreme south-west of Canada.

Thus a flight about five times as long as Amundsen's, eleven years before, was ended almost before the public knew that it had started. Factory whistles shrieked throughout the whole of Russia, and the population made merry in the streets in honour of the three men.

But it was not to be many weeks before the Russians were ready for another flight, and on July 12th a bigger, improved type of machine, ANT-25-1, took off, with Michael Gromoff and two companions on board. Again the flight began at Moscow; the route was planned over the North Pole, and it beat all previous records from the point of view of skilful navigation, and distance. For sixty-two hours the three men were in the air. The engine functioned excellently the whole way, and the plane went on in spite of high winds and changing temperatures which would have been disastrous had the machine not been fitted with the new de-icing apparatus. The world followed Gromoff in its newspapers and wireless-sets, and towards the end a good deal of anxiety was felt, as for many hours no news came from the plane, and no one knew where it was.

At last, after 62 hours' flying, the great red plane alighted among grazing cattle, near San Jacinto, in the southernmost corner of California, a long way south of

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San Francisco. They were received by a single countryman, who asked them furiously what they were doing on his land. None of the Russians could speak any English. Gromoff stammered out the three words 'Bath, Food, Sleep', but the farmer went off and complained to the local police constable. And then explanations followed. A few hours afterwards the roads were blocked with cars and reporters and camera-men, and the air resounded with planes trying to find the landing-place in the fog.

The second Russian transpolar flight had been accomplished. The machine had flown 7,150 miles (as far as from the Orkneys to the Cape of Good Hope), thereby breaking all long-distance records. The Russians rejoiced, and the three men were hailed from the Gulf of Finland to the Pacific. Plans were already started for a regular service to be begun the same summer. Unfortunately, an accident shortly afterwards damped the enthusiasm, and proved that the Russians could not yet altogether rely upon their technicians.

On August 12th, 1937, the famous flyer Sigismund Levanevsky, the 'Lindbergh of the Soviets', took off in a new machine NTE-209 from Moscow. This time no long-distance record was to be attempted; there were to be landings, and the trip was to be an example of a normal passenger flight to America. But four hours beyond the North Pole, Levanevsky's wireless transmitter went out of order, just after he had reported a great loss of petrol and oil. The large-scale search which followed, and which continued during the following months, was without result, and an investigation afterwards made in

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Moscow seemed to show that there had been grave defects in the machine. With the usual Russian thoroughness all the builders of the machine were imprisoned for sabotage, but Levanevsky and his five men were lost. So ended the great flights of 1937, which in the beginning held out such hopes for the future, but which ended by showing that man had not yet conquered the Arctic.

We have heard now about the aerial survey of the Arctic during the last dozen years. Between Amundsen's and Gromoff's flights a tremendous advance had been made. Only a few blank spots remain in the map of the North Polar regions. We have established a series of meteorological stations, which will soon have robbed the capricious Arctic weather of all its secrets. And in the difference between Amundsen's and Gromoff's machines we see how modern technique has been able to adapt planes and engines to Arctic conditions. Levanevsky's fate will therefore have no curbing effect on the further development of Arctic routes, and the day is nearer than is commonly supposed when the centre for journeys between the two hemispheres will be what is now a barren unknown spot in the Siberian tundra.

To speak of the other Arctic expeditions which have been made since 1925 would be an almost impossible task. Not even those directly engaged in work in one or other of the Arctic areas know just what expeditions have succeeded one another within their own domain. But it may be appropriate here to discuss briefly a few individual enterprises which have been distinguished by introducing new methods of exploring, or stand out



ROALD AMUNDSEN



SIR HUBERT WILKINS



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above others by virtue of some especially admirable achievement.

In 1930 a large expedition was led by the German geologist Alfred Wegener, best known for his *Theory of the Drift of the Continents*. In 1912 and 1913 he had wintered with a Danish expedition on the inland ice close by the north-east coast of Greenland, and now conceived of an idea which at first sight seemed quite impracticable. He thought that it should be possible to winter in the middle of this inland ice. In previous years, as has been already said, the American meteorologist Professor Hobbs had worked in Greenland, and had set forth some meteorological theories to explain the formation of cyclones, and thereby the causes of weather-changes over the Atlantic and Northern Europe. To test these theories, of which the main characteristic was the assumption of constant high pressure, or anti-cyclone, above the central ice masses of Greenland, Wegener proposed to erect a station there, while at the same time observations were to be made at coastal stations on the same latitude in the east and west. Many shook their heads at this scheme. The surface of the central part of the inland ice lies at a height of 10,000 feet, so that in the winter the cold would be unendurable. But Wegener's plan was one of genius. It was simply to use the ice itself as a house. When the sun went down in the autumn and it became impossible to live in tents, the scientists were to dig themselves into the ice. They could settle down in underground rooms undisturbed by gales and snow. The plan was carried out, albeit under great difficulties of which the first presented

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itself at the very beginning. When the ship arrived at West Greenland, where the climb up to the inland ice

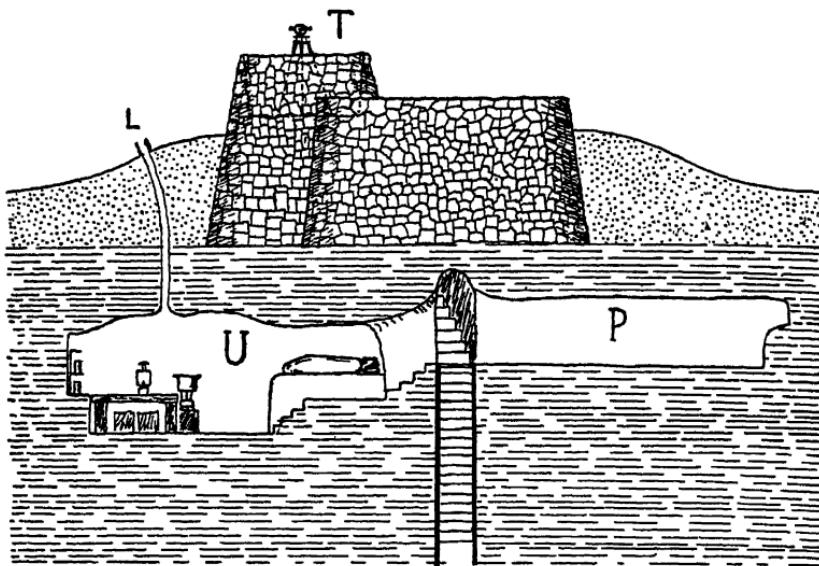


DIAGRAM OF THE 'EISMITTE' STATION

A tower was built of blocks of ice, on which the measuring instruments were set. At T is a theodolite for balloon observations. Behind a sheltering wall is the way down into the ice-hole. At the foot of the steps there is on the left a big store-room P where the provisions are stowed. On the right, at U, is the living-room where the three men lived throughout the winter. On a shelf of ice one of the men can be seen lying in his sleeping-bag. The other two slept one on each side of the table, on which food was cooked over a primus; the home-made lamp was lit for a few hours daily. A shaft leads deeper into the ice, where scientific investigations were carried out. L is an airshaft. The place was a little more complicated than this, however, and contained some smaller rooms not shown in this diagram, including the one in which the gas for filling the balloon was produced.

was to begin, the fjord-ice had not yet disappeared; yet on the other hand, the warm föhn winds had made it too uncertain to be used as a thoroughfare. The steep climb up to the first plateau at 3,500 feet, which had been

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chosen as a transport route, proved almost inaccessible.

For weeks hundreds of men, dogs and horses struggled with the equipment up to the station which was to be built at the edge of the inland ice. The transport of the heavy propeller-sledges in particular, which were adapted only to the even ice-surface farther inland, necessitated almost superhuman efforts, and the whole work was so much delayed that the propeller-sledges were not really brought into use that year. However, the first dog-sledge expedition into the interior was started, with only the most necessary equipment, so that the observations might be begun at once. They were, if possible, to be made throughout the twelve months of the year. Later, a successful attempt was made to convey some more dog-sledges with provisions and equipment. The trail was marked with little black flags, and posts every five kilometres. But enough equipment could not be carried. The boards which were to line the house still lay down at the coast, also the radio transmitter, and provisions were still only scanty by the time the autumn darkness began to settle over the land. Only two months before Christmas, Wegener himself attempted to convey into the interior a load which included fuel for keeping the scientists warm. The attempt was unsuccessful, and the journey cost Wegener and his Greenland companion Rasmus their lives. Wegener was found later in a grave which Rasmus had dug in the ice, but the Greenlander himself had disappeared.

In the 'Eismitte' station, however, three men went on confidently with their winter work. By rationing the

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provisions, they could be made to last until the first relief sledge should arrive in the spring. There was not nearly enough fuel for warming the place, so that the party had to spend most of the time in their sleeping bags. One of them had his feet frost-bitten, and in the course of the winter his companions had to remove his toes, one after the other, without dressings and without anæsthetics, their only instrument being a pair of scissors. Nevertheless day after day, frozen and undernourished as they were, these men carried on their scientific work. The meteorological instruments were kept in operation, and recordings made several times a day. The temperature of the inland ice was measured down to a great depth. A shaft fifty feet deep was sunk, to test variations in temperature, and to see how the snow had been transformed into ice in the course of years. The ice-hole was lit by a lamp made of tins and photographic plates, but this was left burning for as short a time as possible, to save fuel. It was the only source of heat besides the primus, which was in operation during the cooking. In the course of the winter the temperature sank to minus 65° Centigrade, but the men became accustomed to this, and felt it as warm when it rose to minus 25°.

Dr. Georgi, the heroic leader of the Eismitte party, has published his diary of this winter camp, perhaps the most remarkable in the whole history of polar exploration. Notwithstanding the laconic style, one can appreciate what an ordeal those months must have been for the three men, physically and spiritually, and can appreciate their emotion and excitement when on May 7th, after the

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return of the sun, they discerned a dark speck on the horizon, and the two propeller-sledges, with a speed like that of motor-cars, came humming towards the station. They brought the desperately-needed stores, and took the sick Dr. Loewe and Dr. Sorge back to the coast with them. But Georgi had to remain behind to make observations during the final months. He spent the summer alone, perhaps the most solitary man anywhere on the earth, in the midst of a white wilderness, with nothing between him and the horizon but the bare plain.

Another important contribution made by the Wegener expedition must be mentioned. The thickness of the ice was measured: a task which at one time might have seemed impossible. However, now that we have heard of the fathometer, we can understand how it might be done. Naturally no ordinary sound-waves could be sent down and thrown back by the solid rock beneath the ice. More powerful means were used. A charge of dynamite was exploded on the surface of the ice, and the vibrations which radiated out on all sides, and were also thrown back from bed-rock, were measured with the help of an instrument rather like those used in measuring earthquakes. Results showed that the inland ice does not lie on high ground; the weight of it has pressed the earth down so that it is held as in a basin, the bottom of which is no higher than the surface of the sea. That is to say that in the middle this layer of ice has a thickness of over 10,000 feet.

Another expedition of later years is that of the *Nautilus*. Sir Hubert Wilkins, whom we have heard of before, was

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more than just an airman. His bold brain busied itself with other questions too, and a few years ago he conceived another brilliant idea. If it were impossible to make hydrographic investigations from ordinary ships in the Polar Basin on account of the drift-ice, it should be possible to pass under it, in a submarine. Europeans laughed when they heard his plans, but the United States Government was sympathetic, and sold him an obsolete submarine for the nominal sum of one dollar. However, the *Nautilus* proved to be too old and worn out, and Wilkins had some bad luck with her on the preliminary voyage to Norway. Nevertheless, he made a journey to the Arctic regions, where valuable soundings and hydrographic observations were made in the channel between Spitzbergen and Greenland. This expedition has always been regarded as having something rather comic about it, mainly because the public were ignorant of the true circumstances; but it may well be that Wilkins was on the right track. Little imagination is needed to picture the day when a great part of the route between Northern Europe and Canada will be traversed by means of submarines running beneath the drift-ice of the Polar Basin, when Vardö, Cape Chelyuskin and Point Barrow have become important ports for the intercontinental traffic, and the towns on the northern Pacific coasts are in far closer contact with Western Europe than at present. For this reason Wilkins's attempt may be ranked among the most important events of recent polar exploration.

Among other enterprises of the last ten years, the Danish East Greenland expedition may also be noted.

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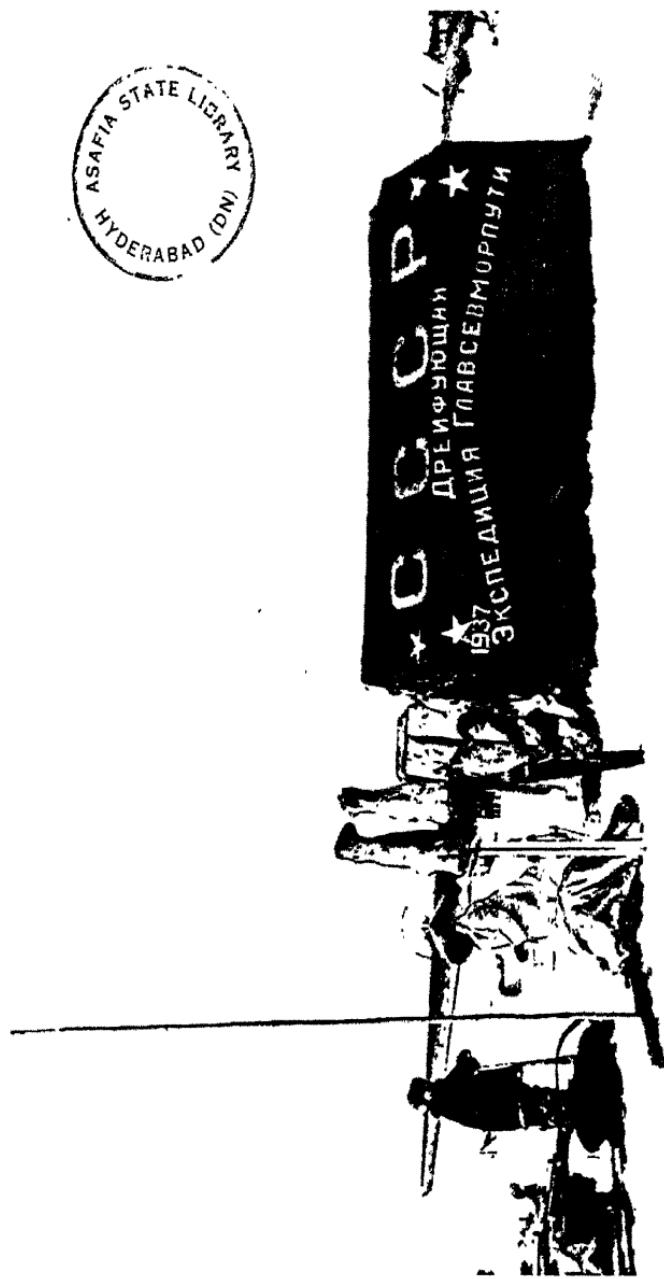
After a few preliminary expeditions, the real work began in 1931, on what was called the 'Three Year Expedition' which during the ensuing years, under the skilled and energetic leadership of Lauge Koch, undertook a comprehensive and thorough investigation of North East Greenland: an enterprise which has been mentioned again and again in this book, and which can stand as a model for the modern Arctic expedition. Not only was the land mapped from the air, but we obtain also a detailed knowledge of its geological formations, its animals and plants, fjords and valleys and its past and present history; so that hardly any other land in the Arctic has been so thoroughly studied as East Greenland. In those great summers of the Three Year Expedition, over a hundred men were working in its service, and the research is still going on. Simultaneously with this, other expeditions were working over territory farther south, under the leadership of such men as Knud Rasmussen and Ejnar Mikkelsen, with the same manifold aims. Finally, in 1933, Lauge Koch undertook some daring flights northward, almost as far as the extreme northerly tip of Greenland, by which we gained some knowledge of the area of which the Danmark Expedition (1906-8) had mapped the coasts, and also an impression of the interesting geological features of these regions.

The last expedition to be mentioned brings us up to last year : 'The Russians on the ice-floe', as it was called in the black type of the headlines. This was without doubt an exploit which can be worthily compared with that of the 'Eismitte' party.

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The expedition started, after a long period of preparation, in March 1937. For the first time no ships were taken up into the Arctic with equipment for the winter-stations, but giant aeroplanes which left Moscow on March 22nd with the members of the expedition and their gear. After a difficult journey, racing the spring which transformed the flying-grounds to a morass, they reached Rudolf Island, the most northerly of Franz Joseph's Land, and therefore the most northerly firm ground in Soviet Russia, being only 550 miles from the North Pole. Here, on the flattened dome of the island, a landing-ground was made which had the advantage of sloping downwards on all sides, but which might be dangerous if the heavily-laden machines could not take off immediately into the air, because this sloping plateau dropped abruptly to the sea. At this place a little fleet of flying-boats assembled in the middle of April. These were the four big four-engined machines, which were to undertake the real Polar flight. Besides this there was a two-engined scout-machine, and two smaller aeroplanes which could be sent out to make observations of wind and ice.

On May 5th, one of the big machines reached the Pole, but landing was impossible owing to fog, and not until the 13th did the flagship of the expedition, N-170, alight on the ice some little way from the Pole itself. On the following day two other planes arrived, one after an intermediate landing; but there was no news of the last machine which had taken off at the same time as the others. It arrived much later, having come down else-



THE WINTER STATION ON THE ICE IN THE EARLY DAYS OF MAY 1937

The tent has just been erected, and the protecting walls of snow have not yet been built. The tent is dark-coloured to absorb the rays of the sun and increase the interior warmth. Paparin has hung a pair of his high skin boots on a pair of skis to dry. In the background can be seen two of the four-engined planes which have not yet left

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where in the polar basin, where a taking-off place had to be made before, with great difficulty, the plane could be got into the air again.

Thirty-five men were now assembled on the ice, and they all set to work to pitch the camp which was to be the home of four of them in the coming winter. About ten tons of goods were unloaded from the machines, consisting of stores for a year. Great quantities of provisions were set out on the ice; sledges and tents, instruments and apparatus were unstowed from the holds of the planes. The work of erecting a house was rapidly put in hand; a house which naturally was very different from earlier winter-stations. It was ten feet long, seven feet wide and just under seven feet high. First, over a framework of duralumin, a layer of waterproof rubber was stretched, then two layers of silk lined with eiderdown. The outer covering consisted of several layers of black canvas. The meteorological instruments were set up, and wireless masts erected on the ice-floe. Three transmitters of different strengths were installed, for which the power was supplied by a wind-driven motor. There was also a petrol-engine for this, and for an emergency a little transmitter worked from a hand-driven dynamo. In the first few days telephonic communication with Moscow was established, and the flight-leader Molokov's little son at home in Moscow telephoned the urgent request that his father should bring him home a polar bear.

The four aeroplanes remained on the ice-floe for sixteen days, while the chief of the expedition gave the wintering-party some final advice. Then the flyers took

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off and made their way southward, while the four men went quietly about their work. At first they were bothered by the excessive warmth of the North Pole, which melted the ice and made their feet wet. But they took their meteorological observations unperturbed, and sent home their report every four hours. Soon the headlines 'Hallo, this is the North Pole' disappeared from the pages of newspapers, and the four men were forgotten by the world. Only the observant reader could find every day in the meteorological section of *The Times* information about the weather at the station, and the station's present position.

For the North Pole Camp did not long remain at the North Pole. The great floe on which the house was built was afloat on an ocean 200 fathoms deep, and the ocean currents were carrying it away, at first a little uncertainly but soon in a definitely southerly direction. In a course which varied slightly they moved over the area between the eighth and tenth longitude west of Greenwich, while the men carried out their work as if they were at a perfectly ordinary meteorological station, of which the Russians have so many along the northern coast of Siberia.

In December, after drifting for more than six months, the destination of the ice-floe was evident. The floe was now between Greenland and Spitzbergen, and on its way to join the East Greenland Polar Current. The days were dark, and the Russians could see little of the Greenland mountains, but they thought they saw another piece of land altogether. At this time they were crossing one of the few areas still represented on the map by a blank.



PROPAGANDA POSTCARD ISSUED IN HONOUR OF THE
FOUR MEN ON THE ICE-FLOE

Reading from top to bottom: Papanin; Krenkel, wireless operator;
Feodoroff, astronomer and magnetician; Sjirsjoff, hydrographer and
doctor

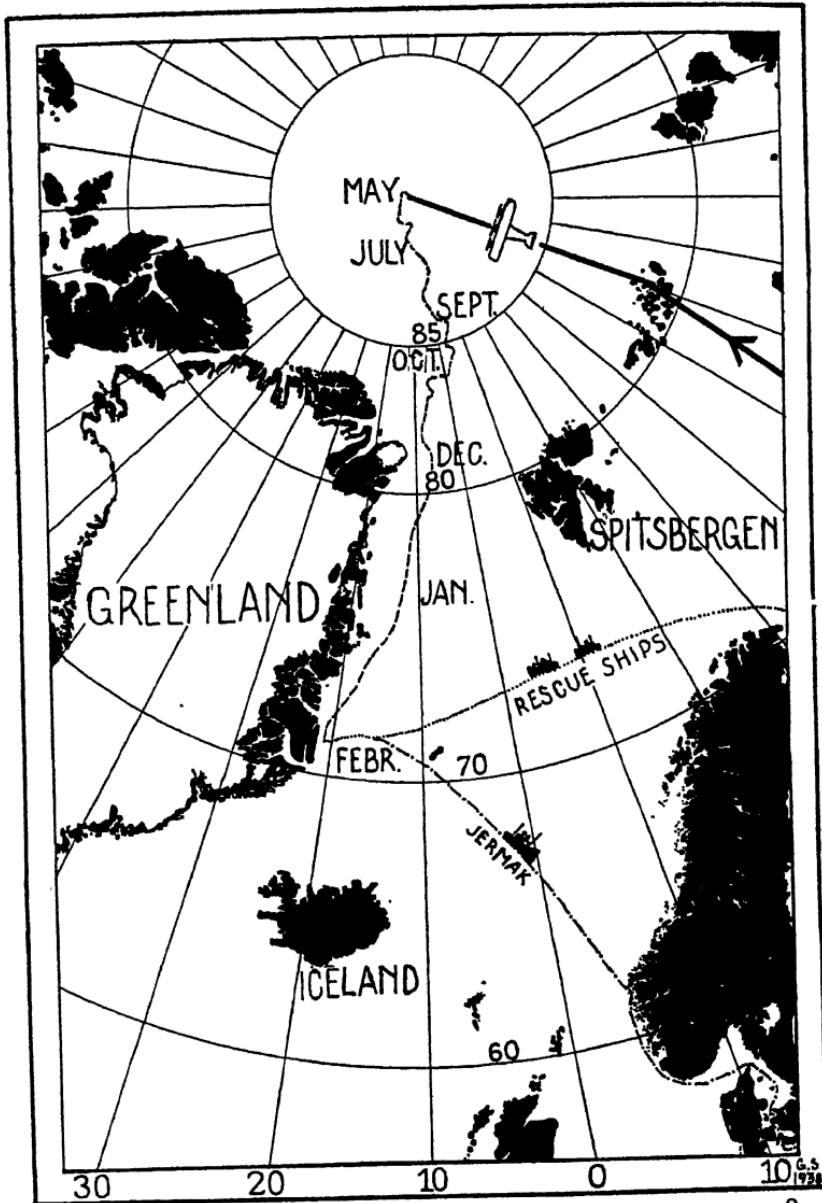


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Here, between North-East Greenland and Spitzbergen, individual explorers had long had the idea that land might exist. The members of the Danmark Expedition called it Fata Morgana, for they never could be quite sure that it was there. Lauge Koch thought he could see it on his flight to Peary Land in 1933. Now through the Norwegian station on Jan Mayen Island came the news from the Russians that they believed they could see land; and those of us who knew the circumstances became interested. The result was the planning of a Danish expedition to these parts. This expedition, which was carried out in May 1938, was led by Lauge Koch on board a Dornier-Wall flying-boat, escorted by a smaller plane and a ship whose base was at a place famous in the history of exploration: Kingsbay, Spitzbergen. From here two big flights were made over to North Greenland, of which one led right up over Peary Land, where interesting geographical observations were made. But the alleged islands proved to be — Fata Morgana.

But we will return to the four Russians, who, having rounded North-East Land, drifted rapidly on southward. Their progress was astonishingly quick; all through January the floe sped along East Greenland, so that by February 1st they had already passed the most northerly inhabited places, at a distance of sixty miles from the shore. And now the floe began to break up. The world was given the alarm, and there was a strong revival of interest in the four men who, apart from their meteorological telegrams, confined their communications to short comments on the fact that the floe was dwindling but

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THE ROUTE OF THE ICE-FLOE, MAY 1937, TO FEBRUARY 1938

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that spirits were high. Norwegians and Danes stationed along the coast offered their help, but Russia preferred to manage it by herself. Expeditions began to be fitted out, and soon a small seal-fisher, the *Murmanetsk* sailed, but became fast in the ice off Jan Mayen at the beginning of February, and drifted south hundreds of miles from those she was to have helped. In the early days of February the ice-breaker *Taimyr* sailed out from Murmansk, followed by another one called the *Murman*, while in Leningrad all haste was being made to fit out the giant ice-breaker *Jermak*. The *Taimyr* was more fortunate than any experienced polar sea-captain would have thought possible. By the middle of the month she had forced her way through the pack-ice, so that she lay only twenty-five miles from the ice-floe, where she was overtaken by the *Murman*. The planes were sent out, and one of them landed near Papanin's camp, bringing beer and goose; but the party would not leave without their instruments. The ice-breakers therefore pursued their way, partly by means of dynamite blasting, through the huge masses of pack-ice.

By February 19th, they had reached the side of a big ice-floe which was seen to be in contact with the winter-station. With the naïve, engaging weakness for effect which characterises the Russians, the rescue itself was now staged. The combined crews of both ships marched in procession over the ice, with a large band at their head. The men fell on each other's necks, wireless waves radiated through the world, and in Russia all the school-children were given a holiday. Krenkel sent a farewell

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greeting to all the wireless-telegraphists who had helped him, and closed down his transmitter. One hour later all the instruments and the precious records were aboard the ships, which now began to make their way out of the ice. The *Jermak*, on her way up over the North Atlantic at the rate of sixteen knots, went to the aid of the little *Murmanetsk*, which had perhaps had the greatest obstacles to overcome, and did not deserve to be forgotten in the general rejoicing. And all the ships steamed home together in triumph.

The results of the ice-floe party are many and important. These consist not only in their meteorological observations round the North Pole, which give us a key to the weather in these regions and consequently in our own regions as well, nor in the record of a drift which may be compared with Nansen's admirable *Fram* voyage. We have gained through this enterprise a series of highly interesting magnetic and hydrographic records; also information as to the life of creatures in the ice and in the water beneath the drifting floes. Most important of all are perhaps the findings relating to the temperatures of the water and the nature of the currents at the North Pole: it was demonstrated that the surface layer of cold water at the North Pole is quite shallow, and that the Gulf Stream sends a powerful current up there. A change has taken place since Nansen's voyage which is of far-reaching importance. No wonder, then, that the civilised world can join with the Russians in delight at the rescue of these men and of results of their work.

If this last enterprise has received more space than the

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others, it is not because it is freshest in the memory. It is that it combines perfectly the technique and organisation of all modern expeditions. Each separate phase in it was a remarkable event in itself. Four big aeroplanes land at the North Pole, the goal aimed at for generations. Throughout the whole winter four men make meteorological recordings and other observations in this region, with the aid of the best equipment known to modern explorers. Four undaunted men make a journey on an ice floe which takes them more than 1,250 miles. And when things began to look threatening, efficient help is at hand, and thousands of horse-power overcome the hitherto unconquered ice in one of the severest months of winter.

Yet we cannot confine ourselves to praising modern methods alone. Throughout the whole of this book, the line has been followed which was laid down in the introduction, that man has become of less importance in his relation to technique and the machine. We have sung the praises of the romance of technique, and established the fact that the romance of the individual hero belongs to the past. In Arctic exploration the machine has indeed become an important factor, nevertheless the example of the four Russians shows that there is still room for the great personal qualities. Men are still willing to risk their lives when by so doing there is a real contribution to be made to modern Arctic exploration.

CHAPTER IX

CONCLUSION

In an amusing and stimulating book called *The Northward Course of Empire*, the polar explorer Vilhjalmur Stefansson has set out his views on the future use of Arctic lands. His way of thinking is an emphatically optimistic one and provokes contention, but it contains nevertheless a number of interesting considerations, and it is amusing to see how the development of the last ten years has followed the course predicted by Stefansson.

The author goes to work in a thorough manner. He begins by talking of the ancient Egyptians and the people of the Persian civilisation, who regarded the regions north of the Mediterranean as the uttermost boundary of the world, beyond which no civilisation could thrive. Time passes, and Greeks and Phoenicians are succeeded by the Roman Empire. For the Romans, the Alps formed an almost insurmountable barrier: north of them came Ultima Thule, whose inhabitants were regarded almost as beasts. Cæsar's expeditions into Gaul and as far as the coasts of Britain remain isolated adventures. These tracts of forest-clad and partly uninhabited country may have been formally incorporated into the mighty Roman Empire, but they were not regarded as being of any economic importance, and that they might one day evolve their own civilisation would have been absolutely unthinkable.

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Nevertheless, the centre of culture rolls smoothly and surely northwards, and it may now, I think, be stated as a fact that in our century the culture is concentrated about the Anglo-Saxon and Scandinavian countries.

But we can go no farther north. Above the Arctic circle live half-civilised people, ice and darkness hold sway there, and it is no place for the white man. To create a civilisation in North Canada, in Greenland or Siberia is out of the question — or such is the common way of thinking to-day. Misunderstanding, superstition, and ignorance, says Stefansson. Men have grown no wiser — they hold the same distorted view as was held by the Egyptians and Persians, the Greeks and the Romans. Stefansson sets himself to clear up this ignorance. First he does it by pointing out the mistakes, resulting from imperfect knowledge, which have been made up to our own day. He points to the civilisation of America. The settlers of the last century arrived at the great prairies, which were regarded as incapable of cultivation. The prairie-belt had to be crossed, and there followed a wandering over deserts until the woods were reached. These were burned to make room for the cultivation of the soil. All the oldest settlements of America lie in the forest belts, and it dawned only gradually on more far-seeing men that prairie-soil was ideal for the cultivation of crops, if only the right methods were used. Now the prairie is an ocean of waving corn, and the woods have leave, to a greater or lesser extent, to grow up again where they belong.

Here also we must clear up false conceptions. It is said

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that it is cold in the Arctic. Yet look for example at Winnipeg which, with its 200,000 inhabitants, is the wheat-centre of the world, and whose temperature falls to minus 40° C. in winter. Again, the Arctic is dark, and no plants can grow there. But what does darkness matter in winter, when plant-life is suspended anyway? On the contrary, we should remember that in summer the sun never sets, and if we get as far as the North Pole we have six months' uninterrupted sunshine, so that what the plants lose on a short summer, they make up by taking in light throughout the twenty-four hours.

One should therefore not believe either that the Siberian tundra is bare and comfortless, or that the Canadian Barren Grounds deserve their name. On the contrary, one finds a magnificent show of vegetation there in the summer: a close carpet of grasses and half-grasses, and flowers of all colours; and in August the wide plains are covered with the gleaming snow of cotton-grass.

There are possibilities for reindeer-breeding on a large scale over these millions of square miles. A. E. Porsild is of the opinion that on the delta of the Mackenzie River alone there is room for a quarter of a million reindeer. And the Mackenzie delta is just a little speck on the map. Stefansson has calculated that methodical breeding on all the now unused areas of Northern Canada would bring in between ten and thirteen million reindeer a year, representing an amount of meat far exceeding all other kinds which at the moment can be produced in the whole of Canada. So that if one could only accustom people to

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eating reindeer meat — which would hardly be difficult, for it is already a prized dish in many parts of the world — it would be possible to reorganise entirely farming in the temperate zone. Cattle-farming would be abandoned, and the land be devoted to the more profitable cultivation of corn, or to an intensive market-gardening, which permits of a much denser population. The same conditions prevail in Siberia, and here reindeer-breeding in the tundra is being expanded, and a large institute for this in Moscow takes the lead in a series of scientific and practical investigations. The first trains with refrigerator coaches are already running between the Arctic and the bigger Russian towns. These facts open up a wide perspective, and suggest a solution to the problem of supplying the densely-populated areas of Europe and North America with meat.

The central part of Siberia is covered with huge forests; indeed, the wooded areas here exceed that of the whole of western Europe. Fifty million trees a year might be felled, and yet leave enough to supply the world with timber for several hundred years to come. It is some of the finest wood in existence, but at the moment it is not worth the expense of transporting it by rail. As in Sweden, it must be floated down the rivers, to be sawn up and sorted at big saw-mills at the mouth and exported by sea. And all Siberian rivers flow into the ice-filled polar basin, which hitherto has been regarded as unnavigable by ordinary merchant ships.

But the Russians have realised that this is the only way in which one can utilise the huge timber resources of

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Siberia. They have therefore lost no time in making a survey of the sea-route north of Asia. Series of hydrographic expeditions are sent out yearly to obtain exact information about currents and ice conditions, while on all the islands in the Arctic Ocean, and at points along the coast, meteorological stations are established which follow minutely the changes in the weather. The whole of this research is grouped under the afore-mentioned 'Glasevmorput', which translated is 'Central Administration for the Northern Sea-Route', and the leader of which is Professor Otto Schmidt.

Sailings from the Pacific and the Atlantic to the Siberian rivers have long been in existence, and are becoming of ever-increasing importance. The foreign freighters are received by big ice-breakers which, piloted by aeroplanes, lead them to the mouths of the rivers, up which even the largest vessels can penetrate a long way inland. Here are the great saw-mills. A town like Igarka, on the River Yenisei, has now 15,000 inhabitants, though six years ago the only dwellers there were a couple of solitary nomadic families. From here more than 500,000 tree trunks are exported annually on foreign steamers.

Geologists have shown that valuable minerals are to be found in many places in the Arctic, like gold in Alaska and Labrador, and oil along the Mackenzie River. There is enough coal in Greenland for the use of the country itself and for shipping. The Kryolite mines at Ivigtut are the biggest in the world, while the newly-opened marble quarry can provide fine building-stone

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for more places than Denmark. On Spitzbergen, both Russians and Norwegians bring to the surface big ship-loads of coal from the mines in Barentsburg and Gromont City, the most northerly mines in the world. Along the north coast of Siberia also, mining towns are springing up. On Taimyr geologists have found nickel and tin, and the big mining-town of Norilsk is growing up here in the middle of the tundra. The little unknown Tixi Bay, near the mouth of the Lena, will also acquire fame in the course of the next few years, chiefly on account of its salt deposits, which will give a strong impulse to the fishing-trade. In former times, the salting of fish was difficult, as the salt had to be brought from the Russian salt mines on the shores of the Caspian, which meant a sea-voyage round Asia. But under the salt lies oil, much desired by the great powers of the world. The significance of this cannot be overlooked. It means that the great Diesel-electric ice-breakers, and all the merchant-vessels, can be fuelled on the spot; and there would be petrol also for the aeroplanes on the transpolar routes, for Tixi lies exactly on the way between Shanghai and New York.

Unfortunately, the strategic importance of the polar regions must also be taken into account. At the back of all the Russian activity along the coast of Siberia there are strong strategical considerations. The Russians mention themselves that the most direct route for bombers from Moscow to Japan passes over North Siberia. Their war-planes have such a wide range that they can fly non-stop from the Tixi oil-depôts to the Japanese towns and back, having discharged their load. And in the case

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of a Baltic blockade the northern sailing route would become of even greater importance than in time of peace. However, in the policy of self-sufficiency, the new finds of metal at Taimyr play the biggest part. So the peaceful scientist works on in the Arctic, as he does in every other part of the civilised world, to make a coming war as effective as possible.

Luckily, we who are young let neither our work nor our happiness be disturbed by the thought of the war which is apparently being prepared for us in the capitals of Europe. Youth has the same instinctive attitude as the ant, which comes running with new building-materials when a kick has scattered its community. This optimism leads us to follow in the footsteps of the old Arctic explorers. We desire to make this part of the world subject to us also, and we take part in modern exploration with all the experience which earlier generations have given us, and with the help of all the miraculous technical knowledge of our own day, in the hope that our work will prove of value to our successors.

